State of Connecticut

PUBLIC DOCUMENT No. 24

Forty-second Annual Report

OF

The Connecticut Agricultural Experiment Station

Being the annual report for the year ended October 31

1918

and including Bulletins Nos. 207 to 214

PRINTED BY ORDER OF THE LEGISLATURE

NEW HAVEN
PUBLISHED BY THE STATE
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PUBLICATION
APPROVED BY
THE BOARD OF CONTROL

PRESS OF
THE WILSON H. LEE CO.

CONNECTICUT AGRICULTURAL EXPERIMENT STATION

OFFICERS AND STAFF

SEPTEMBER 30, 1918.

BOARD OF CONTROL.

His Excellency, Marcus H. Holcomb, *ex-officio, President.*

James H. Webb, *Vice President*............................Hamden
George A. Hopson, *Secretary*............................Wallingford
E. H. Jenkins, *Director and Treasurer*....................New Haven
Joseph W. Alsop...Avon
Wilson H. Lee...Orange
[1]Frank H. Stadtmueller..................................Elmwood
[2]Elijah Rogers..Southington
[3]W. H. Hall...South Willington

Administration.	E. H. JENKINS, PH.D., *Director and Treasurer.* MISS V. E. COLE, *Librarian and Stenographer.* MISS L. M. BRAUTLECHT, *Bookkeeper and Stenographer.* WILLIAM VEITCH, *In charge of Buildings and Grounds.*
Chemistry.	
Analytical Laboratory.	[4]JOHN PHILLIPS STREET, M.S. E. MONROE BAILEY, PH.D., *Chemist in charge.* C. B. MORISON, B.S., C. E. SHEPARD, [5]H. D. EDMOND, B.S., M. D'ESOPO, PH.B. } *Assistants* [6]HUGO LANGE *Laboratory Helper.* V. L. CHURCHILL, *Sampling Agent.* [7]MISS ALTA H. MOSS, *Clerk.*
Protein Research.	T. B. OSBORNE, PH.D., D.SC., *Chemist in Charge.* MISS E. L. FERRY, M.S., *Assistant.*
Botany.	G. P. CLINTON, SC.D., *Botanist.* E. M. STODDARD, B.S., *Assistant Botanist.* MISS F. A. MCCORMICK, PH.D., *Scientific Assistant.* G. E. GRAHAM, *General Assistant.* MRS. L. D. KELSEY, *Stenographer.*
Entomology.	W. E. BRITTON, PH.D., *Entomologist; State Entomologist.* B. H. WALDEN, B.AGR., *First Assistant.* [8]Q. S. LOWRY, B.SC., I. W. DAVIS, B.SC., M. P. ZAPPE, B.S. } *Assistants.* [9]MISS G. A. FOOTE, B.A., *Stenographer.* [10]MISS MARTHA DEBUSSY, *Stenographer.*
Forestry.	WALTER O. FILLEY, *Forester, also State Forester and State Forest Fire Warden.* A. E. MOSS, M.F., *Assistant State and Station Forester.* MISS E. L. AVERY, *Stenographer.*
Plant Breeding.	DONALD F. JONES, S.D., *Plant Breeder.* C. D. HUBBELL, *Assistant.*
Vegetable Growing.	W. C. PELTON, B.S.

[1]Died Jan. 10.
[2]Appointed Feb. 25.
[3]Appointed April 12.
[4]Absent on leave. In service of the United States.
[5]Appointed Feb. 15.
[6]Died Sept. 28.
[7]Appointed Sept. 1.
[8]Resigned March 1.
[9]Resigned Aug. 10.
[10]Appointed Aug. 26.

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ERRATA

10718. Sanderson's Plain Superphosphate was omitted on pp. 129 **and** 130 of the fertilizer report (B. 209). The analysis follows:

		Found %	Guaranteed %
Phosphoric acid,	water-soluble...	10.20	
	citrate-soluble..	5.44	
	"available"	15.64	14.00
	citrate-insoluble	1.09	
	total..........	16.73	

P. 154, under Chittenden's brands:

10878. "Potato Special without Potash" is misbranded. **It should** read Complete Tobacco and Onion Grower without Potash.

Report of the Board of Control

OF

THE CONNECTICUT AGRICULTURAL EXPERIMENT STATION

To His Excellency, Marcus H. Holcomb, Governor of Connecticut:

As required by law, the Board of Control of The Connecticut Agricultural Experiment Station herewith respectfully presents its report for the year ending October 31, 1918.

The following minute, adopted by the Board, records the death, during the year, of one of its members:

Frank H. Stadtmueller, a member of this Board, died at his home on Vine Hill Farm, in West Hartford, Connecticut, January 10, 1918, after a brief illness.

Mr. Stadtmueller was born on the same farm in West Hartford where he spent his mature years.

Early in his life the family moved to New Haven, where his father was for many years clerk of the Sheffield Scientific School and curator of the collections of Professor George J. Brush, the distinguished mineralogist. Here Mr. Stadtmueller received his education, taking courses in the Sheffield Scientific School of Yale University, under Professors Johnson, Brewer, and Oscar Allen.

In 1885 Mr. Stadtmueller returned to the place of his birth and served as farm manager there until his death.

His varied public services can be indicated only imperfectly by the important offices which he filled.

He served his town at various times as one of the selectmen, member of the town school committee, justice of the peace and trial justice, and for fourteen years was the town health officer.

He was also a vestryman in St. James Episcopal Church.

He was for several years president of the Connecticut Dairymen's Association, a member of the Hartford Chamber of Com-

merce, the United States Public Health Association, and of a number of State agricultural organizations.

Mr. Stadtmueller made himself expert in the use of the bacteriological and chemical methods necessary for control of the purity of milk and was the pioneer in the certified milk industry in this State. On the farm under his care he worked out and practiced the methods and technique required to produce milk of the highest degree of purity and taught others the methods and practice. Being an expert in this and other dairy matters, his services as a lecturer were in demand all over New England.

He served as one of three commissioners to codify laws in relation to taxation, and on a committee to investigate and report on laws regarding the taxation of forest land.

For the last six years Mr. Stadtmueller was the State Dairy and Food Commissioner, and brought to this office his intimate knowledge of all matters connected with the dairy interest, study and experience of matters related to the public health, and devotion to the duties of the office.

From 1907 until his death Mr. Stadtmueller was a member of the Board of Control of this Station. His farm experience and wide knowledge of agricultural matters, his appreciation of the value of scientific research and his earnestness in whatever work he undertook, especially fitted him for this place and made him most helpful in it.

A brief recital of the various offices held by Mr. Stadtmueller gives no adequate idea of the service which he rendered. His high sense of honor and of personal responsibility made each appointment to office not a sinecure or a personal tribute to him, but a call to serve others, which he fulfilled to the limit of his ability and often beyond the limits of his physical endurance.

The members of this Board desire to record their deep appreciation of Mr. Stadtmueller's earnest and valuable services to this Station, their tribute to the memory of an able, scrupulously honest, efficient and unselfish public servant, and their deep sense of personal loss in his death.

THE SPECIAL WAR WORK OF THE STATION

John P. Street, chief chemist, was given leave of absence, commissioned captain in the United States Army, and engaged, under the Surgeon-General, in the inspection and control of army rations and food wastes in the cantonments in this country. Promoted to major, he was sent abroad and is serving in France.

C. B. Morison, assistant chemist, was given leave of absence, commissioned lieutenant in the United States Army, and is doing work similar to Major Street's in the American cantonments.

I. W. Davis, in charge of gipsy moth work was given leave of absenee and is a corporal in the United States Marine Corps.

Twelve men employed as laborers in the gipsy moth work have also entered the army or navy.

E. H. Jenkins, director, is the Federal Food Administrator for the New Haven District and is a member of the Food Committee of the State Council of Defense.

W. E. Britton, chief entomologist, is chairman of the Food Committee of the New Haven War Bureau.

W. O. Filley, forester, has served as recruiting officer for the Foresters' Regiment and is a member of the State Fuel Administration.

W. C. Pelton, vegetable expert, is one of the committee assisting in the supervision of gardens in New Haven.

In 1917 the seed corn was greatly damaged by an untimely freeze, and to protect farmers from planting worthless seed this year the Station tested over 1100 samples, chiefly drawn by the County Agents in all parts of the State, reporting each test to the Extension Department of the Agricultural College, to the County Agent and to the owner of the sample. Only one-third of the samples tested was satisfactory, but largely as a result of this work very little poor seed was planted and the corn crop in 1918 is very satisfactory.

Aside from the above direct war services, every member of the staff has devoted much time to special war work.

Of special importance is the work of Dr. Osborne, with the collaboration of Dr. L. B. Mendel, of the Sheffield Scientific School. In our opinion, the greatest service which the Station is rendering in the present emergency, both to agriculture (in the department of

cattle feeding) and to the world, and which will continue to be of special value until the production of human food everywhere has become nearly normal again, is that which Dr. Osborne has done at this Station for the last twenty-five years and more. It was supported for years wholly from State funds, but is now in part supported by the Adams Fund.

This work has established for the first time, with substantial accuracy, the ultimate and proximate composition of a large number of protein bodies, proving that while their ultimate composition is in many cases nearly alike they differ widely in the nature and relative amount of their complex constituent radicals.

There followed a very extensive study of the relative nutritive value of these individual proteins by newly devised methods which, for the first time, made such tests possible, and which incidentally showed the futility of many of the short-time feeding tests which often have been given a confidence which was misplaced.

This study of the nutritive value of different single proteins showed that "protein" was not assimilated as a unit, but rather that each form of protein was a complex of nutrients (amino-acid and bases) from which the required elements were selected by the body, which rejected the others.

The very different requirements for growth and for maintenance have been demonstrated.

By the methods referred to above it has been for the first time possible to determine the relative importance of each mineral element in nutrition.

The nature, the importance, and the relative amount of vitamines existing in various feeds of animal and vegetable origin are being studied.

The application of all this work to the vast problem of feeding our own people and our allies at this time is being made by Dr. L. B. Mendel, who has been collaborating with Dr. Osborne on the physiological side of this project and who is a representative of the United States Food Administration on the Inter-allied Scientific Food Commission, and a member also of the Advisory Committee on Alimentation and of the Advisory Committee of the Home Conservation Division of the United States Food Administration.

The Departments of Station Work

The work of the different departments, so far as it is ready for publication, will appear in bulletins. Only the briefest notice of it can be given here.

Botany

Dr. Clinton in Charge.

Aside from the regular work of experiments and observations on various crops, partly in co-operation with the United States Department of Agriculture, special study has been made of the prematuring and rust of potatoes and of alarming troubles which appeared in July and August, which were proved to be due, not to fungi or insects, but primarily to deficient water supply and also, in some cases, to defective fertilization, especially as regards potash.

While Mr. Stoddard has been chiefly engaged in the field work of scouting, control and eradication of the white-pine blister rust, Dr. Clinton and Dr. McCormick have studied the disease, especially with reference to the manner of infection of both the pine and the alternate hosts—the currant and the gooseberry. They have determined the way in which the pine is infected through the leaves and the formation therein of sclerotia. They have also artificially produced on *Ribes* leaves the second and even the third stage of the fungus.

In co-operation with the United States Department of Agriculture, an extensive Plant Disease Survey of the State has been made.

Messrs. Stoddard and Graham tested over 1100 samples of seed corn sampled by County Agents and others in all parts of the State, in order to insure sound corn for planting. Only one-third of the samples examined was found to germinate satisfactorily.

Chemistry

Dr. Bailey in Charge.

The work of the year, largely under Statute requirements, has involved the examination of 1118 fodder materials, 487 fertilizers, over 2100 food and drug products, and 1419 pieces of Babcock glassware (of which 3.3 per cent. were condemned as inaccurate).

Expert testimony in court has been required in 15 cases.

Some time has been devoted to the study of analytical methods.

To assist the Dairy and Food Commissioner in carrying out the provisions of an Act of Legislature Concerning the Testing of Milk and Cream (Chap. 221, Public Acts of 1917), several examinations have been held in this laboratory in order to test the capacity of persons making milk tests.

An exhibit of cereal breakfast foods has been prepared for the Department of Home Economics of the State Council of Defense for use in connection with their educational exhibit at various fairs in the State.

Numerous investigations of foodstuffs suspected of containing poisonous or injurious substances and also of cadavers suspected of containing poison have been made, upon the request of the State and local Food Administrators, of the Department of Justice, of Public Health and Police authorities, and of private individuals.

Besides the preparation of the bulletins in this report which are credited to him and an article on Food Economy by Substitution, printed in the Monthly Bulletin of the Department of Health, New Haven, February, 1918, Dr. Bailey has also assisted the State Dairy and Food Commissioner and the Director of this Station in the preparation of a revision of the Rules and Regulations relating to the State Food and Drug Law. He is serving as an expert on diabetic foods for the American Medical Association, and as a Referee of the Association of Official Agricultural Chemists.

Entomology

Dr. Britton in Charge.

The inspections required examinations of 88 nurseries, 387 cases of imported stock, and 385 apiaries containing 2913 colonies. Of the latter, less than four per cent. were found infested with disease.

The work of controlling the gipsy and brown-tail moths has been actively prosecuted, in spite of the great difficulty in getting labor. Thirteen men have been employed, and the infestations have been reduced and many eliminated. Slight infestations have been found in seven towns where they had not been previously reported. The Federal Bureau of Entomology has helpfully co-operated in this work.

The mosquito elimination work has been in charge of Mr. Walden, the director's deputy. Little new ditching has been done on account of the labor conditions, but the ditching previously done has been kept in fairly good condition and some new tide-gates necessary for the work have been built, and residents in the shore districts testify to great relief from the mosquito plague during the summer.

Time has been found to study the life history and habits of a sawfly injuring the Austrian pine and a cockroach doing great damage in greenhouses. This work has been done by Mr. Zappe.

Studies have been continued on the insects attacking cucurbits and on the control of the potato aphid and other insects injuring potatoes, and on spraying orchards to control the red bug and aphis.

A survey by the Federal Bureau of Entomology to learn the distribution in Connecticut of the Oriental peach moth has been made, in which the Entomological Department has actively co-operated. Injuries attributed to this insect have been found in twelve of our shore towns, but the insect itself has been found in only one town.

Much emergency war work has been necessary. This consisted of examining gardens, identifying insects, advising control measures, and giving advice and addresses relating to war gardens. In some of this work Dr. Britton has co-operated with the State Council of Defense. He has collaborated with the council in preparing a bulletin on war gardens and in preparing the war garden exhibit at agricultural fairs. He has also been chairman of the Food Committee of the New Haven War Bureau.

Forestry

Mr. Filley in Charge.

Besides the raising of seedlings for use on the Station forest at Rainbow and in the State forests, there have been the clearing of fire-lines and cutting of weeviled tops on the younger pine plantations at Rainbow, and examinations of woodland in order to advise owners as to the handling of the growth.

The work in the five State forests has consisted of getting out chestnut ties and poles and mixed cordwood from the Portland Forest and the planting of 15,500 seedlings on the cut-over tracts;

in the Simsbury Forest 10,000 seedlings were set; but on the other forest areas no extensive work was done aside from the general care of the land.

Six hundred and twenty-six acres have been added to the State forests during the year.

As State Forest Fire Warden the forester has had rather more than usual to do. During the first six months of 1918 there were 889 fires, burning over 33,000 acres and doing damage to the amount of $110,000. Up to September 30th, however, there had been no fall fires, so that the annual loss will not be greater than is usual.

The field work to detect and decrease the white-pine blister rust was in charge of the forester until July, when it was temporarily taken over by Mr. Stoddard. In Norfolk, the most seriously infected spot, the decrease in the number of infections is partly to be attributed to the work of eradication done there last year. In general throughout the State the number of infections of both pine and *Ribes* is less than was the case last year.

Since November 1917 Mr. Filley has served under the Fuel Administrator as chairman of the Committee on "Wood for Fuel", a work which has taken very considerable time.

Plant Breeding

Dr. Jones in Charge.

The investigations on the laws of inheritance in maize and tobacco are being continued, being supported by the Federal grant made exclusively for research work. Particular study has been devoted to the effects of long-continued inbreeding and of subsequent crossing upon the productiveness and other characters of maize. These results have been assembled in the form of a bulletin which is in the process of publication.

The new variety of tobacco produced by the crossing of standard varieties followed by many years of selecting for a uniform and constant type has been grown in two different parts of the State with promising results.

The co-operative corn variety tests carried on at the Storrs and the New Haven Stations have yielded information concerning desirable varieties of corn for Connecticut and sources of seed for next year's planting.

Protein Research

Dr. Osborne in Charge.

During the past year this department has studied the relative nutritive value of the proteins of the more important food products in general use. It has also attempted to establish the distribution and relative proportion in these food products of those recently discovered, but indispensable, food factors, commonly known as vitamines. The results of these investigations, which have been published in scientific journals, are too technical to be further referred to here, but it is believed that they have contributed much of value in the present time of dietary restrictions imposed not only on man but on farm animals by scarcity of supplies and prevailing high prices.

Market Gardening

Mr. Pelton in Charge.

Experimental work has covered certain variety and strain tests of tomatoes, beans, beets, lettuce, radishes, cabbage, witloof chicory, melons, and celery, the last named in co-operation with three other New England states. The sweet-corn cross of Stowell's Evergreen and Golden Bantam has been subjected to an ear-to-the-row test to separate the strains. Six varieties of beans and four of sweet potatoes were planted on sandy land in four localities to determine their usefulness on such soils. Brief studies have been made of the vitality of sweet corn seed when variously treated.

As secretary of the Connecticut Vegetable Growers' Association the market gardener has conducted its correspondence, assisted at the annual meeting in February, 1918, and arranged two field meetings during the summer and fall.

In his capacity of chairman of the Sub-committee on War Gardens, of the New Haven War Bureau, the market gardener has had general oversight of the activities of the committee and has largely outlined its policies.

The Field Meeting

The annual field meeting was held at the Mount Carmel Farm on August 20th. About four hundred people were present and examined the work which was in progress there. After the lunch,

Hon. J. W. Alsop, chairman of the State Council of Defense, made the principal address, on "Connecticut Agriculture in Relation to the War".

To carry out the field work properly has been extremely difficult because of the absence of all good farm labor, but under Mr. Hubbell's management the experiment work has not suffered and our aim to raise more food than ever has been carried out.

Changes in the Station Staff

The absence of those engaged directly in the United States service has been already noted.

On September 28th Mr. Hugo Lange, an assistant in the chemical laboratory, died suddenly at his home. For thirty years he had been employed by the Station in work which required absolute honesty, accuracy and diligence. In none of these things did he ever fail.

Following the destruction in November of the chemical laboratory used by the Storrs Agricultural Experiment Station, the chemist, Mr. H. D. Edmond, came to New Haven, where he is employed by both Stations under an arrangement by which the chemical work of the Storrs Station will be done wholly at this Station for the present.

Mr. Waldo L. Adams, assistant chemist, resigned in November; Mr. Q. S. Lowry, assistant in entomology, in March, and Miss Grace A. Foote, stenographer, in August. All of them resigned to accept much more adequate salaries elsewhere.

Publications

In the interest of economy the Station has adopted the plan of printing its bulletins as a part of its report, so that all accounts of the Station work appear either in its annual reports or in the publications of various scientific journals.

The Station report contains eleven bulletins, aggregating 478 pages, with 37 full page plates, which, with the usual reports of treasurer and director, together with the index, makes a volume of 526 pages. One Bulletin of Immediate Information (No. 8) on the diseases of bees and their treatment has also been issued.

Following is a list of papers published by members of the Station staff in scientific and other journals within the last twelve months. These could not be printed by the Station within the limits imposed by law, and the larger part of their contents is of immediate value to investigators rather than to farmers.

From the Protein Research Laboratory.

In the Journal of Biological Chemistry:

The Proteins of Cow's milk. Osborne and Wakeman. 1918, **XXXIII**, pp. 7–17.

Some New Constituents of Milk (Third Paper). Osborne and Wakeman. 1918, **XXXIII**, pp. 243–251.

The Growth of Chickens in Confinement. Osborne and Mendel. 1918, **XXXIII**, pp. 433–438.

The Role of Some Inorganic Elements in Nutrition. Mendel and Osborne. 1918, **XXXIII**, p. iii.

Nutritive Factors in Animal Tissues (II). Osborne and Mendel. 1918, **XXXIV**, pp. 17–27.

The Inorganic Elements of Nutrition. Osborne and Mendel. 1918, **XXXIV**, pp. 131–139.

Nutritive Factors in Plant Tissues (I). The Protein Factor in Seeds of Cereals. Osborne and Mendel. 1918, **XXXIV**, pp. 521–535.

Milk as a Source of Water-Soluble Vitamine. Osborne and Mendel. 1918, **XXXIV**, pp. 537–551.

The Choice Between Adequate and Inadequate Diets, as Made by Rats. Osborne and Mendel. 1918, **XXXV**, pp. 19–27.

In the Journal of Pharmacology:

The Growth of Chickens under Laboratory Conditions. Mendel and Osborne. 1918, **XI**, p. 170.

In the American Journal of Physiology:

Nutritive Factors in Some Animal Tissues. Mendel and Osborne. 1918, **XLV**, p. 539.

From the Plant Breeding Department, by Dr. Jones.

Bearing of Heterosis on Double Fertilization.
Botanical Gazette, April, 1918, **65**: 324-333.

Segregation of Susceptibility to Parasitism in Maize.
American Journal of Botany, June, 1918, **5**: 295-300.

The Effects of Inbreeding and Crossbreeding (An Abstract).
Proceedings of the National Academy of Sciences, August, 1918, **4**: 246-250.

Review of Coulter and Coulter's "Plant Genetics".
Science, N. S., October 4, 1918, **48**: 346-347.

Some further idea of the miscellaneous work of the Station may be gathered from the following statistics:

Number of letters written	9,109
Public addresses	49
Papers in scientific journals	15
Popular articles in other publications	21
Specimens of insects and fungi identified for inquirers	501
Specimens added to herbarium	2,457*
Samples of seed tested	1,228

In the summer of 1917 the Connecticut State Department of Health asked if this Station could furnish quarters for the Bureau of Health Laboratories. The Station Board of Control, recognizing the value of this central location and of the other facilities which the city and the grounds of this Station afforded, and believing that this was the most desirable place to locate all of the scientific work required by the State, put at the disposal of the Health Department the ground floor and basement of the frame laboratory building, which has been occupied for the Health Department's uses since September 1, 1917.

All of which is respectfully submitted.

George A. Hopson,
Secretary.

New Haven, Connecticut, October 31, 1918.

*Of these, 1,278 were given by Dr. Clinton from his private herbarium.

REPORT OF THE TREASURER, 1918.

E. H. Jenkins, in account with the Connecticut Agricultural Experiment Station for the fiscal year ending September 30, 1918.

Receipts

Balance on hand, October 1, 1917 (Analysis Fees)		$454.11
State Appropriation, Agriculture	$18,750.00	
State Appropriation, Food	2,500.00	
State Appropriation, Insect Pest	6,000.00	
United States Appropriation, Hatch	6,875.00	
United States Appropriation, Adams	6,875.00	
Analysis Fees	12,400.00	
Connecticut Agricultural College	1,000.00	
Miscellaneous receipts	436.95	
Lockwood Trust Income (including sale of wood and Mt. Carmel Farm produce, $1,500.85)	15,000.85	
		$69,837.80
		$70,291.91

Disbursements

E. H. Jenkins,	director, salary	$2,800.00
E. H. Jenkins,	treasurer, "	400.00
V. E. Cole,	salary	1,067.00
L. M. Brautlecht,	"	657.00
J. P. Street,	"	500.00
T. B. Osborne,	"	2,400.00
E. M. Bailey,	"	2,315.00
C. B. Morison,	"	1,595.00
C. E. Shepard,	"	1,309.15
W. E. Britton,	"	2,600.00
G. P. Clinton,	"	2,600.00
E. M. Stoddard,	"	1,378.13
W. O. Filley,	"	2,491.66
A. E. Moss,	"	1,850.00
E. L. Ferry	"	1,320.00
D. F. Jones,	"	1,700.00
W. L. Adams,	"	216.66
Michael D'Esopo,	"	950.00
Florence McCormick,	"	641.67
W. C. Pelton,	"	2,000.00

H. D. Edmond, salary	$816.64
B. H. Walden, "	83.33
Hugo Lange, "	1,059.90
V. L. Churchill, "	1,045.00
William Veitch, "	770.00
Etta L. Avery, "	528.00
C. D. Hubbell, "	880.00
G. E. Graham, "	935.00
C. A. Gallastegui, "	150.00
Alta H. Moss, "	164.00
Mrs. L. D. Kelsey	468.00
Henry Kiley	902.00
Frank Sheldon	902.00
O. J. Welch	902.00
T. F. Barrows	476.57
Theodore Gonier	445.00
Labor	4,225.75
Publications	360.27
Postage	327.26
Stationery	394.89
Telephone and Telegraph	217.60
Freight and Express	189.20
Gas, Electricity and Kerosene	1,288.15
Coal	4,153.06
Water	155.85
Chemicals	799.60
Laboratory Supplies	346.33
Agricultural and Horticultural Supplies	105.31
Miscellaneous Supplies	747.83
Fertilizers	643.30
Feeding Stuffs	587.77
Library and Periodicals	239.34
Tools, Machinery and Appliances	324.82
Tools, Machinery and Appliances (Repairs)	716.11
Furniture and Fixtures	395.88
Furniture and Fixtures (Repairs)	62.01
Scientific Apparatus	301.52
Scientific Apparatus (Repairs)	84.63
Travel by the Board	182.07
Travel by the Staff	628.45
Gasoline for Automobiles	434.97
Travel in connection with Adams Fund Investigations	74.00
Insurance	1,032.34
Insect Pest Appropriation to State Entomologist	6,000.00
Contingent	423.57
Buildings and Land (New Buildings)	2,640.93

Buildings and Land (Betterments)..........	$199.54	
Buildings and Land (Repairs)..............	381.94	
Total Disbursements..................		$69,983.00
Balance on hand, Sept. 30, 1918 (Analysis Fees)		308.91
		$70,291.91

New Haven, Conn., Oct. 18, 1918.

This is to Certify that we have audited the accounts of Mr. E. H. Jenkins, Treasurer of the Connecticut Agricultural Experiment Station, for the fiscal year ending September 30, 1918, and have found them correct.

William P. Bailey,
James P. Tobin,
Auditors of Public Accounts.

CONNECTICUT

AGRICULTURAL EXPERIMENT STATION

NEW HAVEN, CONN.

BULLETIN 207 SEPTEMBER, 1918

THE EFFECTS OF INBREEDING AND CROSSBREEDING UPON DEVELOPMENT

BY

D. F. JONES

The Bulletins of this Station are mailed free to citizens of Connecticut who apply for them, and to others as far as the editions permit.

CONNECTICUT AGRICULTURAL EXPERIMENT STATION

OFFICERS AND STAFF

BOARD OF CONTROL.

His Excellency, Marcus H. Holcomb, *ex-officio*, *President*.

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Elijah Rogers..Southington
William H. Hall...................................South Willington

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The Effects of Inbreeding and Crossbreeding Upon Development.*

INTRODUCTION.

Among the higher seed plants certain groups are characterized by almost universal and continuous self-fertilization. On the other hand certain other groups are completely, or to a large extent, cross-fertilized in every generation. Between these two extremes every gradation in the degree of self- and cross-fertilization can be illustrated. The structure and function of the floral organs have become more or less clearly adapted to the customary mode of sexual reproduction characteristic of each species. In the thallophytes, bryophytes and pteridophytes much the same situation exists whereby the gametes which enter into a sexual fusion may arise either from the same or from different organisms.

In the lower animals the same variation in the mode of sexual reproduction exists as in plants. Among the higher animals, however, hermaphroditism is replaced entirely by bisexuality; and sexual reproduction, except when parthenogenesis takes place, results only from the union of gametes originating in different organisms.

This array of facts has naturally led to searching inquiries as to the purpose of sexual reproduction as compared to other methods of propagation as well as to the effects of artificial inbreeding in bisexual animals and in naturally cross-fertilized plants. Bound up with this latter problem is that which is concerned with the effects of cross-fertilization in all types of animals and plants of different degrees of relationship.

The development of the Mendelian theory of heredity, carrying with it the conception of definable, hereditary units which are sufficiently stable in their transmission from generation to generation to be recognized and their somatic expression to be described,

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* Submitted to the Faculty of the Bussey Institution of Harvard University in partial fulfillment of the requirements for the degree of Doctor of Science, December, 1917.

has made possible an attack upon these problems which has opened a way towards their solution.

From the knowledge of alternate inheritance it is possible to ascribe, very definitely and surely, certain of the results of inbreeding to the segregation and isolation of hereditary factors which results were formerly thought to be due solely to inbreeding as a cause in itself. Certain pathological, abnormal or otherwise undesirable conditions occurring more frequently in animals and plants produced by matings between nearly related individuals were formerly attributed to inbreeding as the cause, and it was thought that inbreeding must always show such undesirable results. It is now known that many of these pathological and abnormal conditions resulting from inbreeding do not owe their origin to that process, but are due solely to the segregation, into a pure state of the hereditary factors causing the anomalies which factors were present in the organisms previous to their being inbred. Inbreeding, then, has nothing to do with the origin of the undesirable characters under consideration but merely brings them into visible expression, and whether or not they appear depends upon their presence originally in the stock before inbreeding takes place. There still remains a conviction, however, that all the manifestations attending inbreeding and the converse effects of cross breeding cannot be accounted for solely on the basis of the operation of definable, hereditary factors, but that there is a stimulating effect resulting from crossing, which is lost by inbreeding, and that this stimulation differs somewhat from the expression of hereditary factors which can be transferred and fixed in different organisms. This stimulation is supposed to be of a physiological nature appearing when dissimilar germ-plasms are united, and disappearing as the germinal heterogeneity disappears in subsequent recombinations.

Since this physiological stimulation has always been purely hypothetical, having never been definitely proven, and since it has been used to account for certain facts heretofore inexplicable in any other way, the existence of such a stimulation may fairly be questioned, in so far as the facts can be logically accounted for in other ways. Recent advances in the knowledge of the methods of inheritance have made it possible to meet certain objections previously held against the view that the effects of inbreeding and crossbreeding can be attributed solely to the

operation of hereditary factors without assuming an additional hypothetical stimulation.

Some of the previous work bearing upon the effects of inbreeding and crossbreeding is reviewed here and with this are given original data obtained from the naturally cross-fertilized corn plant, *Zea mays* L. The facts at hand co-ordinate with the existing knowledge of heredity in such a way that it seems to the writer unnecessary any longer to make the fundamental distinction between the effects of inbreeding and crossbreeding and of heredity in development.

No attempt is made to canvas the extensive literature on hybridization (a bibliography of which alone would fill a volume) in order to list all the cases in which crossing does or does not result in increased development and inbreeding in a reduction. It does not take one long in reading over the many published results of crossing in animals and plants to become convinced that an increase in development following a cross is a frequent occurrence. It is hoped that sufficient references are given to show something as to the universality and nature of the phenomenon and a review of the more important contributions is made in order to sketch briefly the development of the ideas concerning the cause of the stimulation and the part it has played in evolution and in breeding practice.

The experiments on inbreeding, which have resulted in the material from which the data given here have been gathered, were started by Professor E. M. East at the Connecticut Agricultural Experiment Station and carried on by him and subsequently by Professor H. K. Hayes and later by the writer. From time to time reports on these experiments have been made and conclusions drawn from the facts as observed. These include various publications under the titles "Inbreeding in Corn," "The Distinction between Development and Heredity in Inbreeding" published by Professor East in the Report of the Connecticut Experiment Station and in the American Naturalist and "Heterozygosis in Evolution and in Plant Breeding" by Professors East and Hayes in a Bureau of Plant Industry bulletin. Under the title of "Dominance of Linked Factors as a Means of Accounting for Heterosis" the writer had proposed a different view as to the cause of hybrid vigor. This was published in Genetics and its application is discussed here in more detail.

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Early Investigations with Plants.

Certain evidence remains from the carvings of the ancient Egyptians to show that they had some conception of a sexuality in plants. However, it was not until the last of the 17th century, when Camerarius first demonstrated such condition, that interest in the production of artificial hybrids began. It is significant that the first artificial hybrids to be systematically studied, those of Kölreuter (1776), furnished some of the best examples of heterosis. Kölreuter made many interspecific crosses in *Nicotiana, Dianthus, Verbascum, Mirabilis, Datura and others,* many of which astonished their producer by their greater size, increased number of flowers and general vegetative vigor, as compared to the parental species entering into the cross. Concerning one of the tobacco crosses he says: (pp. 57–58) "Hybrids obtained from the cross of *Nicotiana maj.* ♀ and *glut.* ♂ produced a far greater number of flowers and grew to an uncommonly greater height and a much greater circumference than the pure species

Further publications are planned which will discuss more adequately much of the data which are scantily treated here.

The significance which these investigations may have for the practical improvement of plants and animals has only been briefly alluded to here. This phase of the subject has been reserved for another time when the methods which have suggested themselves as the result of these investigations have been more thoroughly tested. Finally this collection of facts and theories should be viewed as a report of progress rather thân a well rounded presentation of the subject of inbreeding and crossbreeding.

The writer is especially indebted to his predecessors whose work has made these experiments possible. Grateful acknowledgement is due Dr. E. M. East for his careful supervision of the work and for his kindly advice and helpful criticism as to the presentation of the results obtained. The writer alone, however, must assume the responsibility for the opinions expressed. Much credit is due Mr. C. D. Hubbell, Dr. Charles Drechsler and Mr. G. A. Adsit for their careful assistance in the collection and preparation of the data.

Definitions.

The knowledge of a stimulating effect resulting from a cross between different animals and between different plants which gives progeny which may excel their parents in general vigor, size or other visible characteristics has naturally led to the use of terms to describe this effect. This stimulation is variously spoken of as "vigor due to crossing" or "hybrid vigor." Since hybrid vigor occurs only in crosses of which the parents are dissimilar in hereditary constitution more exact and comprehensive terms were needed. The zygote resulting from a union of unlike gametes is spoken of as a heterozygote (following the usage of Bateson), hence the term heterozygosis (used by Spillman, '09) refers to that germinal heterogeneity which results from the union of unlike gametes, and the stimulation to development which accompanies such a condition is spoken of as a "stimulus of heterozygosis," or "heterozygotic stimulation," meaning the stimulating effects of hybridity or the stimulation due to differences in uniting gametes. The converse fact of a reduction in vigor accompanying a return to a homozygous condition is therefore said to be due to,

or result from, homozygosis. Shull ('14) has proposed the term "heterosis" to designate this increase in development which may result from a heterozygous condition; hence, heterosis, as used here, will be considered synonymous with "hybrid vigor" or "stimulus accompanying heterozygosis," in whatever form this may be manifested or whatever cause or causes it may be due to. Shull proposed this term, as he says, ". . . .to avoid the implication that all the genotypic differences which stimulate cell-division, growth, and other physiological activities of an organism, are Mendelian in their inheritance and also to gain in brevity of expression. . . ." Hence the term heterosis is not meant as a mere contraction of heterozygosis and is not synonymous with it. The adjective "heterotic" has also been proposed and such an expression as "heterotic stimulation" is synonymous with heterosis.

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Thomas Andrew Knight (1799) was one among several at that time who experimented with hybrids with the view of producing more desirable varieties of vegetables, flowers and fruits. Knight observed many instances of high vigor resulting from crossing; among these we note the following remarks about a cross between two varieties of peas.

(P. 200) "By introducing the farina of the largest and most luxuriant kinds into the blossoms of the most diminutive and by reversing this process, I found that the powers of the male and female in their effects on the offspring, are exactly equal. The vigor of the growth, the size of the seeds produced, and the season of maturity, were the same, though the one was a very early, and the other a very late variety. I had, in this experiment, a striking instance of the stimulative effects of crossing the breeds; for the smallest variety, whose height rarely exceeded two feet, was increased to six feet; whilst the height of the large and luxuriant kind was very little diminished."

It is evident that, in these crosses, Knight was dealing with dwarf and standard peas and the dominance of standardness is expected. A sufficient number of cases, however, were observed in which the crosses were more vigorous than an average of the parents to convince him that "nature intended that a sexual intercourse should take place between neighboring plants of the same species." It was this principle which Darwin elaborated 50 years later.

Sageret ('26) reports vigorous hybrids in *Nicotiana* and also between different types of the Cucurbitaceae. Among other things he notes that in human crosses between one individual which shows a hereditary pathological condition and a normal individual, that the disease disappeared in the first generation but reappeared in the second and following generations. Wiegmann ('28) gives instances of hybrids in the Cruciferae which showed distinct evidences of heterosis.

Probably the most extensive series of experiments on hybridization were those of Gärtner ('49) and of Focke ('81). According to Lindley ('52) Gärtner made 10,000 crosses between 700 different species and produced 250 different hybrids. Many of these hybrids showed distinct evidences of heterosis, and this phenomenon was manifested in many different ways. Gärtner speaks especially of their general vegetative luxuriance, increase in root development, in height, in number of flowers and their hardiness and early

and prolonged blooming. Focke made equally extensive observations and catalogues his own experiments with many of those made previously. His valuable book shows clearly that the phenomenon of heterosis is widespread and may be expected in the gymnosperms and pteridophytes as well as in the angiosperms. Both the works of Gärtner and of Focke have been so thoroughly reviewed in recent times (East and Hayes '12) in connection with the problem in hand that it would be a needless repetition to say more about their results here. Special points in their observations, as they supplement the experiments recorded here, will be referred to later.

While the work of Gärtner and Focke must always rank high as contributions to our knowledge of genetics one cannot refrain from remarking that they both missed by their extensive studies of many species the point which Mendel discovered by his intensive and careful study in one species.

Naudin ('65) next to Mendel will always be remembered, no doubt, as the first to conceive of a method in the uniformity of the first generation and the variability of the second. His conception of the segregation of parental qualities as a whole leads up naturally to Mendel's law whereby the characters of the parents segregate as units and when finally appreciated the chaotic observations of Gärtner, Focke and their contemporaries began to be understood as orderly facts. In Naudin's classical experiments there are many excellent examples of heterosis. Out of 36 interspecific crosses which he made in *Papaver*, *Mirabilis*, *Primula*, *Datura*, *Nicotiana*, *Petunia*, *Digitalis*, *Linaria*, *Luffa*, *Coccinea* and *Cucumis*, 24 show positive evidence of heterosis. Among the most notable crosses in this respect was that of *Datura Stramonium* with *D. Tatula* in which both reciprocal hybrids were twice as tall as either parent. Concerning the Datura crosses Naudin says:

"A shape very much taller than the two parental types, and the premature falling off of the flowers in the first dichotomies, which leads to tardy fructification are the principal characteristics of this hybrid of which all the plants in the collection present the greatest uniformity. We shall see that these different characteristics appear in all the hybrids of this section of the genus Datura."

Mendel ('65) also records instances of heterosis in his pea hybrids as is shown in the following passage:

"The longer of the two parental stems is usually exceeded by the hybrid, a fact which is possibly only attributable to the greater luxuriance which appears in all parts of plants when stems of very different lengths are crossed. Thus, for instance, in repeated experiments, stems of 1 foot and 6 feet in length yileded without exception hybrids which varied in length between 6 feet and 7½ feet."

The Observations of Darwin upon Plants.

Of all the contributors to our knowledge of the effects of inbreeding and crossbreeding no one has collected as many facts as Darwin ('75, '77). Although undoubtedly much confusion and misunderstanding have resulted from Darwin's conclusions on this problem, one cannot but admire his painstaking efforts to accumulate facts from the behavior of many species of plants through many generations of crossing and selfing before advancing his conclusions. No one was more frank to acknowledge the discrepancies between the facts as he found them and the conclusions he drew from them. Those parts of his results which were not clear to Darwin are clearer to us through our knowledge of Mendelism of which he was not permitted to know. Since his method of experimentation, and the results obtained are familiar to all interested in the problem at hand no extensive review of his work is necessary. Only a brief summary of the results obtained and the conclusions which he drew from them will be given here, reserving a more detailed review of special parts for a later part of this paper.

Among animal breeders in Darwin's time it was a common belief that whatever evil effects resulted from more or less close inbreeding were due to the accumulation of abnormal, diseased, or morbid tendencies in the offspring of parents which possessed such tendencies. Darwin refused to ascribe any large part of the effects of inbreeding to this cause because he knew so many cases were weakened and reduced types of both plants and animals which gave vigorous progeny when crossed among themselves. Instead of an accumulation of the undesirable traits of both parents the very reverse seemed to be true. Had Darwin known of the way by which recessive characters may exist for many generations without making their appearance, doubtless his views on this point would have differed materially.

Darwin clearly thought that the evil effects of inbreeding kept on accumulating until eventually a plant or animal propagated

in that manner was doomed to extinction. His own results came far short of proving such an assumption. The two wild plants with which inbreeding was practiced the longest—*Ipomea* and *Mimulus*—showed very little further loss of vigor after the first generation. What these experiments did show, most clearly, was that there was segregation of the inbred stock into diverse types which differed in minor, visible, heriditary characters and which also differed in their ability to grow. In both species plants appeared which were superior to other plants derived from the same source and some were even equal or superior in vigor to the original cross-pollinated stock. They differed from this race, however, most noticeably in the uniformity of all visible characteristics.

After several generations of inbreeding Darwin found that it made no difference in the resulting vigor, whether the plants in an inbred lot were selfed or were crossed among themselves. This he correctly attributed to the fact that the members of such an inbred strain had become germinally alike. From his views on the effect of the environment on organisms, it is easy to see why he attributed this approach to similarity in inherited qualities to the fact that the plants were grown for several generations under the same conditions. This view he thought was supported by the fact that crosses of his selfed lines with the intercrossed lines (also inbred, but to a less degree) did not give as great increase in vigor as the crosses of either lines with a fresh stock from distant regions. The crosses between two inbred lines did give a noticeable increase in vigor, in many cases, equaling the original variety. This is illustrated in the *Dianthus* crosses in which the selfed line was crossed with the intercrossed line and with a fresh stock. The ratio of both crosses to the selfed plants in height, number of capsules and weight of seed produced is as follows:

	Selfed X Inter-crossed	Selfed X Fresh stock
Height, compared to selfed................	100:95	100:81
No. Capsules, compared to selfed...........	100:67	100:39
Weight of seed, compared to selfed..........	100:73	100:33

Like Darwin we now attribute the greater increase of vigor in a cross with distinct stocks to a greater germinal diversity although we may differ in our ideas as to the way in which that

diversity was brought about. Whatever may be the explanation of that, credit is due Darwin for being the first to see that it was not the mere act of crossing which induced vigor but the union of different germinal complexes. This he states clearly in the following sentences (Cross and Self Fert., p. 270):

"These several cases taken together show us in the clearest manner that it is not the mere crossing of any two individuals which is beneficial to the offspring. The benefit thus derived depends on the plants which are united differing in some manner, and there can hardly be a doubt that it is in the constitution or nature of the sexual elements. Anyhow, it is certain that the differences are not of an external nature, for two plants which resemble each other as closely as the individuals of the same species ever do, profit in the plainest manner when intercrossed, if their progenitors have been exposed during the several generations to different conditions."

Recent Investigations with Plants.

Although Darwin was the first to attack the problem from the standpoint of determining the effects of inbreeding, it is doubtful if he clearly recognized that the same phenomenon was concerned in both inbreeding and crossbreeding. It remained for Shull ('08, '09, '10, '11 and '14), East ('08, '09) and East and Hayes ('12) to bring out clearly the fundamental similarity of both processes and to put the matter in such a light that a far clearer understanding of the nature of the effects of inbreeding has resulted.

Their conclusions in regard to the causes of the effects of inbreeding and crossing were for the most part entirely new and dependent for their support upon the Mendelian principle of the segregation and recombination of inherited qualities as independent units and upon Johannsen's genotype conception of heredity. Stated briefly their main tenets, based upon their own careful experiments and a survey of previous results bearing upon the problem, are as follows:

1. Inbreeding automatically sorts out into homozygous, pure breeding lines, the diverse and variating complex of hereditary characters found in a naturally cross-pollinated species.

2. Although complete homozygosity is difficult to attain in practice, after several generations of selfing, members of the resulting inbred lines are uniform among themselves but the respective lines may differ greatly among each other in visible

hereditary characters. The strains may also differ in their power of development, some being larger, stronger and more productive than others at normal maturity. Some individuals are often isolated which are so lacking in necessary characters that they perish because of inability to reproduce themselves.

3. Those inbred strains which are able to survive finally become constant; no further reduction in vigor or change in visible characters is to be expected by continued inbreeding. These constant types are thus quite comparable to naturally self-fertilized species and may exist indefinitely.

4. When these pure breeding types are crossed there is commonly an immediate and striking increase in general size and vigor to be expected in the resulting first hybrid generation.

To account for this increase in development, following a cross, a physiological stimulation was postulated which accompanied heterozygosity of hereditary factors and disappeared as the organisms approached homozygosity. As an illustration the union of factor "A" with it allelomorph "a" was considered to evolve developmental energy which was lacking when either "A" or "a" were united with themselves. This stimulus to development was considered to be due to the union of unlike factors alone and to have an effect quite different from whatever part each factor had by itself in the development of the organism. Stated in their own words the main conclusions of East and Hayes ('12) are as follows (p. 8):

"1. Mendel's law—that is, the segregation of character factors in the germ cells of hybrids and their chance recombinations in sexual fusions—is a general law.

2. Stimulus to development is greater when certain, or possibly all, characters are in the heterozygous condition than when they are in a homozygous condition.

3. This stimulus to development is cumulative up to a limiting point and varies directly with the number of heterozygous factors in the organism although it is recognized that some of the factors may have a more powerful action than others."

It was clearly apparent to recent investigators that many of the unfavorable characters which appear on inbreeding a naturally cross-pollinated species are recessive characters which are segregated out of the original complex. In a naturally crossed species, these are hidden from sight on account of being continually

crossed with dominant characters. That dominance of factors could in any way be an essential factor in the vigor and excellence of hybrids, an idea first proposed by Keeble and Pellew ('10) and also by Bruce ('10), has not been accepted by most writers on this subject. They considered dominance to be totally inadequate to account for the widespread and almost universal occurrence of heterosis in plants and animals and the fact that nearly all naturally cross-fertilized domesticated species are reduced by inbreeding.

Collins ('10) has shown clearly that many crosses between varieties of Indian corn already widely crossed among themselves and grown in the same regions may not give any increase in productiveness, but when these same varieties are crossed with varieties from distinct geographical regions great increases in productiveness are obtained. Further evidence as to the occurrence of heterosis is seen in the many publications which have appeared from time to time urging the commercial utilization of this hybrid vigor as a method of increasing production in many plants. Among these are Beal ('76–'82), McCleur ('92), Morrow and Gardner ('93–'94), Swingle and Webber ('97), Hayes and East ('11), Hartley ('12), Wellington ('12), Hayes ('13), Hayes and Jones ('16).

In view of the innumerable cases in which an increase in development, in some character, results from crossing and the converse fact of reduction following subsequent inbreeding, of which the preceding paragraphs refer to only a small fraction, it is surprising to note such radically diverse opinions as are held by Burck ('08) and championed by Stout ('16).

Stout attributes the following statements to Burck: (p. 418)

> "That (1) plants that are regularly self-fertilized show no benefits from crossing and that (2) nowhere in wild species is there evidence of an injurious effect from self-fertilization, and that there is abundant evidence of continued vigor and high fertility resulting from long continued self-fertilization."

If by the first statement is meant that crossing between members of the same variety or between individuals of a uniform species does not give an increase in development such a result would be expected because of the germinal similarity brought about by long continued selfing and elimination by selection, either natural

or artificial, of all but one type. On the other hand, there is abundant evidence to show that crossing between different varieties or between different wild species of self-pollinated plants often results in striking increases in size and vigor. It is only necessary to refer to the work of Kölreuter, Knight, Gärtner, Naudin and Mendel where many crosses between different species or between distinct types of *Nicotiana, Pisum,* and *Lathyrus*—plants which are naturally self-fertilized—give unmistakable evidence of heterosis.

Turning to the effects of inbreeding, almost no long-continued experiments have been carried out with strictly wild cross-pollinated species of plants. Collins ('18) in a brief note states that teosinte, a semi-wild relative of maize, is not affected by inbreeding to the extent that maize is. That there is "abundant evidence of continued vigor and high fertility resulting from long continued self-fertilization" no one longer doubts. There is, however, hardly enough evidence from plants, so far on record, to justify the sweeping statement, which the quotation implies, that cross-fertilized wild species are never reduced by inbreeding.

What evidence there is indicates that naturally crossed wild species are not reduced by inbreeding to anything like the extent that domesticated races are. More will be said about this difference between wild and domesticated races later. There is some evidence, however, to show that strictly wild species are affected by inbreeding. Darwin compared the progeny of artificially self-fertilized plants with the progeny of artificially intercrossed plants of many wild species. Many of these species were such as were for one cause or another almost completely cross-fertilized in their natural state at all times. Although the difference may be slightly exaggerated there can be no question but that the difference in the first generation which Darwin obtained between the selfed plants and the intercrossed plants represents in many cases the effect which inbreeding has upon these plants. As examples of widely crossed wild species in which a reduction in the first generation of inbreeding was obtained by Darwin, one can, therefore, cite: *Digitalis purpurea, Linaria vulgaris, Sarothamnus scoparius* and *Reseda lutea.*

Moreover, no matter how much domestication may change plants from the wild, one cannot cast aside, as of no consequence, the results obtained from cultivated plants.

Investigations with Animals.

According to Darwin, the mule, that classic example of hybrid vigor, was known in the time of Moses, when its hardihood and general good qualities doubtless endeared this animal to the Jews no less than to the Southern cotton planters of to-day. A similar cross of the ass with the wild zebra according to Riley ('10) gives a first generation hybrid animal of considerable merit.

In the early history of the establishment and fixation of breeds of livestock we note in Darwin's "Animals and Plants under Domestication" that certain crosses between different breeds often resulted in progeny excelling individuals of either parent breed; just as to-day it is not an uncommon practice for livestock raisers to cross certain well-established breeds to produce crossed animals to feed for market.

In looking over the reports of experiments designed to test the effects of crossing in both wild and domesticated animals there is little disagreement as to the results usually obtained. All are practically in accord that crossing diverse breeds or races of animals, if not too distantly related, may frequently result in vigorous, large and fertile offspring, excelling either parent in one or more respects. For example, Castle et al ('06) find that crossing diverse stocks of Drosophila results in an increase in fertility and that matings between different inbred lines give progeny with increased fertility up to or beyond that of the more fertile parental race. In Meriones Bonhote ('15) states that fertility and size are increased by crossing. Castle ('16) has crossed domesticated races of guinea-pigs with the wild species from Peru with the result that there is a noticeable increase in body weight over either pure parent. Gerschler ('14) crossed different genera of fishes and obtained large increases in size in the first hybrid generation. *Xiphophorus strigatus*, of which the males were 43.0 cm. long and the females 52.0 cm., when crossed with *Platypoecilius maculatus*, of which the males were 26.0 and the females 31.0 cm. in length, gave hybrid males 54.0 cm. and females 57.5 cm. He speaks of their "gigantic size."

Fischer ('13) in his study of the Rehoboth hybrids, a race in South Africa resulting from a mixture of Hottentots and Boers, states that their average height is somewhat greater than either the Hottentots or the Hollanders and South Germans of whom

statistics are available. All the members of this new race are not first generation crosses by any means, but they are not many generations removed and crossing with the pure Hottentots, the shorter parental race, is frequent.

When, however, the literature on the effects of inbreeding in animals is examined one finds the greatest diversity of facts and opinions. We find the extreme views of Kraemer ('13) who states that "continued inbreeding always must result in weakened constitution, through its own influence" together with the equally extreme and biased opinion of Huth ('75) that in mankind there is no injurious effect resulting from consanguineous marriages which cannot be accounted for on other grounds.

Crampe ('83), Ritzema-Bos ('94), Guaita ('98), Fabre-Domengue ('98) and Weismann ('04) by inbreeding mammals and birds found that the process was accompanied by decreased fertility, attended more or less commonly by lack of vigor, diminution in size, and pathological malformations. Castle, Carpenter et al ('06) inbreeding extensively the fruit fly, Drosophila, maintained fertility by selection, so that at the end of 59 generations of brother and sister matings in one line the fecundity was no less at the end of the experiment than it was at the start. There was some indication of reduction in size of inbred flies when compared to normally crossed stock flies reared under the same conditions. Furthermore, fertility was increased by crosses between certain inbred lines and between the inbred lines and stock flies. From this fact and from the fact that their experiments show that the number of flies in a brood fluctuates greatly, due to temperature and food conditions, it is not positive that inbreeding was wholly without injurious effects. It is evident that their experiments do show clearly:

1. That inbreeding results in strains of unequal fertility.

2. That the occurrence of absolute sterility was pronounced in the first part of the experiment with the "A" line but almost entirely disappeared in the later part of the experiment. The figures as I have calculated them from their table I, p. 736, are as follows:

		Percent of matings totally sterile
Generations	6 to 24	17.80
"	25 to 42	18.47
"	43 to 59	3.37

This result is to be expected on the view that inbreeding isolates homozygous individuals and these whenever sterile are, of course, eliminated.

Moenkhaus ('11) and Hyde ('14) by similar inbreeding experiments with Drosophila have also found that sterility is increased in the first stages of inbreeding but tends to be eliminated after this process is long continued. Hyde found definite evidence that inbreeding caused reduction in size, vigor, rate of growth, longevity and fecundity and that there was a return to the normal condition on crossing. As in the other experiments Hyde found that selection was an effective agent in controlling sterility.

Both Whitney (12a) and A. F. Shull (12a) have shown that inbreeding and crossbreeding have considerable effect upon the rotifer, *Hydatina Senta,* in the size of family, number of eggs laid per day, rate of growth and in the difficulty of rearing the animals.

King ('16) has obtained results with albino rats which are quite in agreement with those of Castle. By growing about one thousand rats in each inbred generation, and selecting the best individuals for mating, animals have been carried through 22 generations of brother and sister matings without loss of size, fertility, longevity, resistance to disease and with constitutional vigor unimpaired. This writer states:

"The results so far obtained with these rats indicate that close inbreeding does not necessarily lead to a loss of size or constitutional vigor or of fertility, if the animals so mated came from sound stock in the beginning and sufficient care is taken to breed only from the best individuals."

Here, as in Drosophila, inbreeding isolates diverse types of different degrees of excellence. In this case individuals are obtained which surpass the original stock before inbreeding. Thus we have "Goliaths" among inbred rats as Darwin found "Heroes" in morning-glories.

Castle ('16) has found that in inbred rats "races of fair vigor and fecundity can be maintained under these conditions, but that when two of these inbred races are crossed with each other, even though they have their origin in a small common stock many generations earlier, an immediate and striking increase of fecundity occurs."

The evidence from relationship marriages in human stocks is even more conflicting and conclusions still more difficult to draw. Huth ('75) has certainly done a service in showing that consan-

guineous marriages seldom result in the disastrous effects usually attributed to them. He has shown that incest was not a rare custom and that races which have undergone such practices are many of them far from weak. Certainly, races have practiced close intermarriage for many generations with no marked deterioration. The Persians, Spartans, the ruling classes among the Egyptians and Polynesians are cited by Huth in support of this assertion. The data from human matings, however, are of little value since the close unions are seldom continued many generations in succession, and the results from isolated communities mean little, since often the original stock is exceedingly diverse so as to make the resulting races extremely heterogeneous in hereditary constituents. This is particularly true of the Rehoboths and the Pitcairn Islanders which are cited as instances of close intermarrying without loss of racial vigor.

Looking over the experiments upon animals it seems as unwise to expect that inbreeding may not have some deleterious effects, which, in some cases at least, cannot be overcome by the most rigid selection, as it is to hold that inbreeding must always result injuriously. It is to be expected that all breeds of domestic animals and wild species will not be equally affected by inbreeding. Domesticated animals in many cases are more widely crossed and diversified than wild species, and those characters affected by inbreeding are more accentuated. Certain wild species, which, by their mode of life, are forced to endure long periods of isolation, and consequently more or less close inbreeding, would be expected to show less change under artificial inbreeding. Finally, as I shall attempt to show that there is no longer a question as to whether or not inbreeding, *in itself*, is injurious, the effect which inbreeding will have on any organism depends solely on the hereditary constitution of that organism at the time the inbreeding process is commenced.

Universality of Heterosis.

From the literature on the subject of crossbreeding it is to be observed, therefore, that the occurrence of an incentive to increased development accompanying germinal heterogeneity is widespread, as it has been noted in plants in the angiosperms, gymnosperms and pteridophytes, and according to Britton ('98)

there is even some slight evidence that heterosis occurs in the sporophyte of the bryophytes.

In animals the mammals, birds, fishes, insects and rotifers show the phenomenon of heterosis although in some of the unicellular animals, as we shall see later, the evidence is not so clear.

I shall now take up, in some detail, experiments on inbreeding and crossbreeding in cultivated plants, principally in maize.

A Theoretical Consideration of Inbreeding.

Up to the present time it has been maintained that the effects of inbreeding were of two kinds, an isolation of homozygous biotypes together with a loss of a physiological stimulation which was considered to be roughly proportional to the number of heterozygous allelomorphs present in the organism at any time. The reduction of the number of heterozygous allelomorphs in an inbred population is automatic and varies with the closeness of inbreeding.

Pearl ('15) on the basis of the number of ancestors which make up the pedigree of any individual has worked out a coefficient of inbreeding which is an indication of the degree to which that individual has been inbred. The fewer the number of ancestors the greater the degree of inbreeding which may vary from no inbreeding, in which no one ancestor appears more than once in the pedigree of an individual, to the closest kind of inbreeding in which no more than one ancestor is concerned in any one generation in the production of an individual (self-fertilization). The latter degree is only approached by hermaphroditic plants and animals, which are capable of self-fertilization and in functionally bisexual animals and plants by brother and sister matings. This statement of inbreeding must, of course, leave out of consideration any germinal change which might take place by means other than hybridization and as Castle ('16) has pointed out is modified by the differences in heterozygosity of the ancestors making up the pedigree.

The automatic reduction in the number of heterozygous allelomorphic pairs in an inbred population, by self-fertilization, follows the well known Mendelian formula by which any heterozygous pair forms in the next generation 50 percent homozygotes and 50 percent heterozygotes in respect to that pair. Since the homozygotes must always remain homozygous and the heterozygotes are halved each time and one half added to the homo-

zygotes the reduction in the number of heterozygous elements proceeds as a variable approaching a limit by one half the difference in each generation. The curve illustrating this condition is shown as No. 1 in Fig. I. Various formulæ dealing with

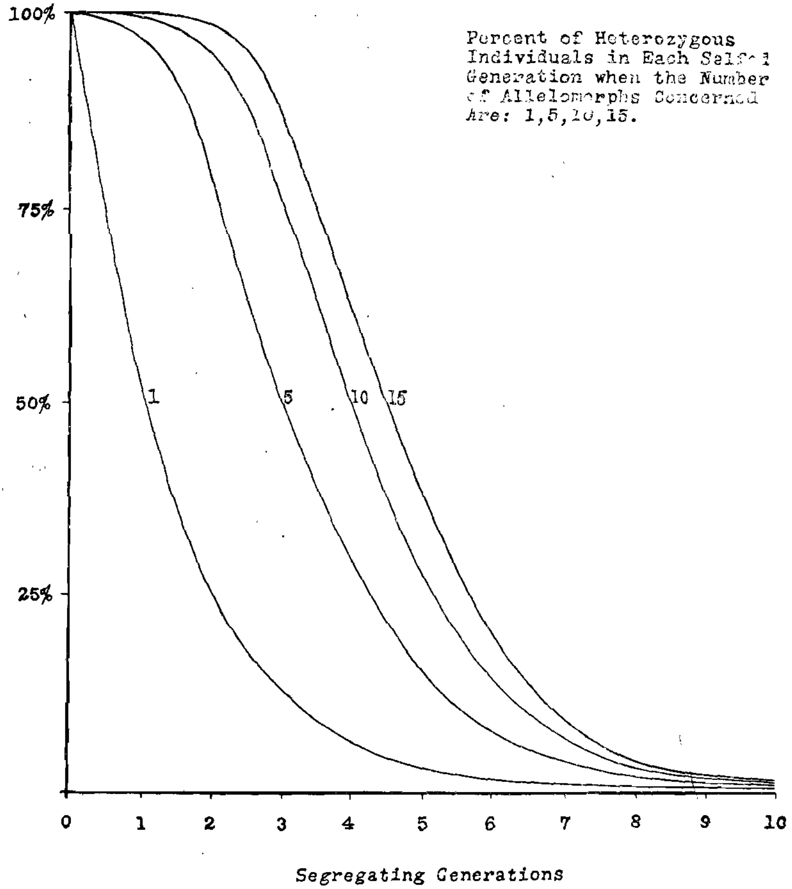

Figure I. The percent of heterozygous individuals and the percent of heterozygous allelomorphic pairs in the whole population in each generation of self-fertilization.

inbreeding have been discussed by East and Hayes ('12), Jennings ('12, '16), Pearl ('15) and Bruce ('17).

It should be remembered that this reduction applies only to the whole population in which every member is inbred and all

the progeny grown in every generation. In practice, in an inbreeding experiment, only one individual in self-fertilization or two individuals in brother and sister matings are used to produce the next generation. Thus the rate at which complete homozygosis is approached depends on the heterozygosity of the individuals chosen. Theoretically in any inbred generation the progenitors of the next generation may either be completely homozygous or completely heterozygous or any degrees in between depending upon chance. The only condition which must follow in self-fertilization is that no individual can ever be more heterozygous than its parent but may be the same or less. Thus it is seen that inbreeding, as it is practiced, may theoretically never cause any reduction in heterozygosity, or it may bring about complete homozygosity in the first inbred generation. In other words the rate at which homozygosity is approached may vary greatly in different lines. However, as the number of heterozygous factors at the commencement of inbreeding increases the more nearly will the reduction to homozygosity follow the curve shown because the chance of choosing a completely homozygous or completely heterozygous individual in the first generations will become less.

In Table 1 is shown the theoretical classification of the progeny of a self-fertilized organism which was heterozygous with respect to 15 independent mendelizing units. It will be seen that the bulk of the individuals lie between classes 6 and 11 where none of the members are heterozygous for more than 10 factors nor less than 5. In other words any individual selected for the progenitor of the next generation would probably come from the middle classes and therefore it would be heterozygous for about half the factors that its parent was. The chance that this individual would not come from the mid-classes between 6 and 11 would be about 1 out of 10. The chance that it would be completely homozygous or completely heterozygous would be 1 out of 32,768. If 20 instead of 15 factors were concerned the chances would be 1 out of 1,048,576.

This condition by which the progenitor of each generation tends to be half as heterozygous as its parent holds true for any number of factors and in every generation. Also in Table 1 it can be seen that the progeny as a whole has an equal number of heterozygous factor pairs as homozygous factor pairs in respect to those

TABLE 1. THE THEORETICAL NUMBER AND RATIO OF INDIVIDUALS IN THE CLASSES OF DIFFERENT DEGREES OF HETEROZYGOSITY, AFTER RECOMBINATION, WHEN FIFTEEN MENDELIZING UNITS ARE INVOLVED.

Class No.	The total number of individuals in all the possible mendelian recombinations in F_2 when 15 factors are involved.	Ratio of individuals in the classes with different number of heterozygous and homozygous factors-coefficients $(a+a)^{15}$	The number of factors in respect to which the different classes are:		The total number of heterozygous and homozygous factor pairs in all the individuals in each class:	
			Heterozygous	Homozygous	Heterozygous factor pairs	Homozygous factor pairs
1	32,768	1	15	0	15	0
2	491,520	15	14	1	210	15
3	3,440,640	105	13	2	1,365	210
4	14,909,440	455	12	3	5,460	1,365
5	44,728,320	1,365	11	4	15,015	5,460
6	98,402,304	3,003	10	5	30,030	15,015
7	164,003,840	5,005	9	6	45,045	30,030
8	210,862,080	6,435	8	7	51,480	45,045
9	210,862,080	6,435	7	8	45,045	51,480
10	164,003,840	5,005	6	9	30,030	45,045
11	98,402,304	3,003	5	10	15,015	30,030
12	44,728,320	1,365	4	11	5,460	15,015
13	14,909,440	455	3	12	1,365	5,460
14	3,440,640	105	2	13	210	1,365
15	491,520	15	1	14	15	210
16	32,768	1	0	15	0	15
16 (n+1)	1,073,741,824 $(2^n)^2$	32,768 2^n	15 n	15 n	245,760 $\frac{1}{2}(n.2^n)$	245,760 $\frac{1}{2}(n.2^n)$

characters in which the parent was heterozygous. So it is that in practice the reduction in growth accompanying inbreeding (on the assumption that heterosis is correlated with heterozygosity) is greatest at first, rapidly becomes less and finally ceases for all practical purposes.

If there were no deviating factors the curve of reduction should, in the majority of cases, approximate curve 1 in Fig. I. However, it has never been assumed that the amount of heterosis was perfectly correlated with the number of heterozygous factors. Moreover, since the heterozygous individuals are more vigorous than the homozygous, selection, either unconscious or purposeful, would favor the more heterozygous so that the tendency might be that the actual approach to homozygosity would not proceed at as fast a rate as the theoretical curve would indicate.

Self-fertilization is the quickest and surest means of obtaining complete homozygosis for the reason that whenever any pair of allelomorphs becomes homozygous it must always remain so long as self-fertilization takes place, whereas in brother and sister mating a homozygote may be mated to a heterozygote. Thus we see from Jennings' ('16) tables that 6 generations of self-fertilization are more effective than 17 generations of brother and sister matings in bringing about homozygosis. The reduction in heterozygous allelomorphs in a population as a whole follows curve 1 in Fig I irrespective of the number of factors concerned, provided, as stated before, that a random sample of all the different classes of individuals are selfed and used as progenitors for the next generation and that there is equal productiveness and equal viability. If the heterozygotes are more productive, as in many cases they are, the reduction to complete homozygosity will be delayed.

The number of completely homozygous individuals in any generation, inbred by self-fertilization, differs according to the number of heterozygous factors concerned at the time that the inbreeding process is commenced. The curves showing the reduction in the number of individuals heterozygous in any factors, where, 1, 5, 10 and 15 factors are concerned at the start are given in Fig. I calculated from the formula given by East and Hayes ('12). The curve for the reduction in heterozygous individuals, where one factor only is concerned, is identical with the curve showing the reduction in heterozygous factors in an inbred population

where any number of factors are concerned. In any case almost complete homozygosity is reached in about the tenth generation on the average, although theoretically it may be reached in the first generation, or may never be reached when a single individual is used in each generation to perpetuate the line.

Assuming, then, that the loss of the stimulation, accompanying heterozygosity, is correlated with the reduction in the number of heterozygous allelomorphs we should expect to find the decrease of heterosis greatest in the first generations, rapidly becoming less until no further loss is noticeable in any number of subsequent generations of inbreeding, and that, on the average, the loss will become negligible at about the eighth generation and from then on no further marked change will take place. Some cases are to be expected in which stability is reached before this generation and some cases in which it is not reached until later or may even theoretically never be reached. With these assumptions in mind let us see what are the actual results of long continued inbreeding in maize.

The Results of Inbreeding the Naturally Cross-pollinated Maize Plant.

The behavior of maize during six generations of inbreeding by self-fertilization has already been reported by East and Hayes ('12). The same inbred strains have been continued and in some cases the results up to the eleventh generation are given here.

In the previous publication it was stated that a loss of vegetative vigor has followed every case of inbreeding in maize. Some plants had been obtained which were unable to reproduce themselves. Those strains which were maintained became uniform but differed considerably from each other. It was considered at the end of the period of inbreeding that some strains were appreciably better than others in their ability to yield. Six additional years of inbreeding with this material has confirmed, in the main, these conclusions. A further appreciable reduction in productiveness, however, has taken place in all lines together with certain changes in various parts of the plants.

The original experiment began with four individual plants obtained from seed of a commercial variety of Leaming dent corn grown in Illinois. This variety was given the number 1

and the four plants which were self-pollinated and selected for continuation of the inbreeding experiment were numbered 1-6, 1-7, 1-9 and 1-12. These four strains were continued each year by self-pollination. In the second inbred generation two self-pollinated plants in the 1-7 line were saved for seed and from them two inbred lines were split off which therefore came originally from one line inbred two generations. These are numbered 1-7-1-1 etc. and 1-7-1-2 etc. In a similar way these, and the other inbred lines, were further split up in subsequent generations. After the experiment was started with the dent corn inbreeding was commenced with other material. Two inbred strains of floury corn, Nos. 10-3 and 10-4, originally from the same variety, have been maintained and also two strains of flint, Nos. 5 and 29, and two strains of popcorn Nos. 64 and 65. Chief attention has been paid to the inbred strains of Leaming corn (the longest inbred) and most of the data presented here have resulted from this material. Many other varieties besides these have been inbred for many generations in connection with other investigations and while they are not specifically mentioned the observations as a whole include these.

In Tables 2 and 3 the yield and height of some of these inbred strains are given. In 1916 seed of the original Leaming variety was obtained which had been grown in the meantime in the same locality whence it was originally secured and was grown for comparison with the inbred strains. This variety in Illinois in 1905 yielded at the rate of 88 bushels per acre, and in Connecticut in 1916 at the rate of 74.7 bushels. While there is no proof that any change has not taken place in the original variety there is no reason to suppose that it has changed to any great extent. Grown under the same conditions in 1916 the four inbred Leaming strains yielded from one-third to one-half as much as the original non-inbred variety.

With regard to rate of reduction in yield or the constancy of the varieties during the later generations it is difficult to draw conclusions from these figures owing to the fluctuation in yield from year to year due to seasonal conditions and to the difficulty of accurate testing in field plot work, which is recognized by all who have made such tests. As was stated in the first report the yields for 1909 were too low and in 1911 much too low on account of poor seasons. No yields were taken on any of the strains in

TABLE 2. THE EFFECT OF INBREEDING ON THE YIELD AND HEIGHT OF MAIZE.

ır wn	No. of generations selfed	Four inbred strains derived from a variety of Leaming dent corn.							
		1-6-1-3-etc.		1-7-1-1-etc.		1-7-1-2-etc.		1-9-1-2-et	
		Yield bu. per acre	Height inches	Yield bu. per acre	Height inches	Yield bu. per acre	Height inches	Yield bu. per acre	H i
6	0	74.7	117.3	74.7	111.3	74.7	117.3	74.7	1
5	0	88.0	....	88.0	....	88.0	....	88.0	..
6	1	59.1	....	60.9	....	60.9	....	42.3	..
8	2	95.2	....	^{1907}59.3	....	^{1907}59.3	....	51.7	..
9	3	57.9	....	^{1908}46.0	....	^{1908}59.7	....	35.4	..
0	4	80.0	....	63.2	....	68.1	....	47.7	..
1	5	27.7	86.7	25.4	81.1	41.3	90.5	26.0	
2	6	....	....	....	....	....	....	^{1913}38.9	..
3	7	41.8	....	39.4	....	....	....	^{1914}45.4	
4	8	78.8	96.0	47.2	83.5	58.5	88.0	^{1915}21.6	..
5	9	25.5	....	24.8	....	....	....	^{1916}30.6	
6	10	32.8	97.7	32.7	84.9	19.2	86.9	^{1917}31.8	
7	11	46.2	103.7	42.3	78.6	37.6	83.8	....	..

TABLE 3. THE EFFECT OF INBREEDING ON THE YIELD OF MAIZE.

Year grown	No. of generations selfed	Two inbred strains of floury corn		One inbred strai flint corn
		10-3-7-etc. Yield bu. per acre	10-4-8-etc. Yield bu. per acre	5-8-6-etc. Yield bu. per acre
1908	0	70.5	70.5	75.7
1909	1	56.0	43.0	47.5
1910	2	67.0	48.7	36.1
1911	3	39.1	29.3	11.5
1912	4	....	....	....
1913	5	32.2	49.5	30.4
1914	6	....	52.6	38.1
1915	7	....	....	....
1916	8	13.9	16.6	18.3
1917	9	26.6	24.0	......

1912. The yields in 1914 are too high and in 1915 too low for the same reasons. Also in 1915 the yields are unreliable because only a few plants were available to calculate yields from as most of them were used for hand pollination. During the last three years of the test samples of corn have been dried to a uniform moisture basis and the yields calculated to bushels of shelled corn per acre with 12 per cent. moisture. This has probably had a tendency to reduce the yields somewhat as these inbred strains are very late in maturing and consequently contain large amounts of water.

With these points in mind an examination of the table shows that from the beginning of the experiment to the ninth generation there has been a tremendous drop in productiveness, so that in that generation the strains are approximately only one-third as productive as the variety before inbreeding. From the ninth to the eleventh generation there has been at least no reduction in productiveness, and practically no change in visible plant or ear characters.

In the previous publication it was stated (U. S. Dept. of Agric., B. P. I. Bull. 243, pp. 23-24) that

> . . . . "strain No. 6, is a remarkably good variety of corn even after five generations of inbreeding. It yielded eighty bushels per acre in 1910. The yield was low in 1911, but since all yields were low that year it can hardly be doubted that this strain will continue to produce good normal yields of grain......The poorest strain, No. 12, is partially sterile, never fills out at the tip of the ear and can hardly exist alone. In 1911 it yielded scarcely any corn but will no doubt continue its existence as a partly sterile variety."

These statements will have to be modified somewhat. Although No. 6 is, in the eleventh generation, still the most vigorous inbred strain, as a producer of grain, however, it can hardly be considered to give "good normal yields." The plants, nevertheless, are perfectly healthy and functionally normal in every way except for an extreme reduction in the amount of pollen which they produce. The strain No. 12 was lost. Since the difficulty of carrying along any inbred strain is very great owing to failure to pollinate at the right time, attacks of fungus on the ear enclosed in a paper bag, and poor germination in the cold, wet weather common in New England at corn planting time, the loss of this strain might be easily accounted for without supposing that it

simply ran out. It may be that this strain could have been perpetuated if sufficient effort had been put forth to do so. In view of the further reduction in the other strains, however, the maintaining of this strain would have been extremely difficult.

Complete records on the height of plant are wanting for many of the generations, and, unfortunately, in the first part of the inbreeding period. What figures are available certainly show that very little change in height has taken place in all four strains during the last seven generations. Strain No. 6 has increased in height, if anything. Height is less affected by environmental factors than is yield and in that respect is a more reliable indicator. However, great changes in the structure, size and productiveness may take place without height of plant being greatly altered.

From the figures given in Table 2 there is some evidence that these strains have reached about the limit of reduction in productiveness and that there has been very little change in the last three years. This, however, is not proven. The continuation of inbreeding is necessary for conclusive evidence on this point. As the crosses between individual plants within these inbred strains have given very little increase over the selfed strains, as will be shown later, and from the fact that almost no visible change has taken place in these four strains during the past three years that I have had them under observation, it seems apparent to me that the reduction in vegetative vigor and productiveness is very nearly at an end.

In Tables 4, 5, 6 and 7 are given the frequency distributions of height, length of ear, number of nodes and the number of rows of grain on the cob of the original, non-inbred Leaming variety and several inbred strains derived from this variety after nine or ten generations of selfing. All the plants from which the data were taken were grown on the same field in the same year. Four different plots of the variety were grown in different parts of the field and the data on these plots are given separately and totaled in the tables. It can be seen from these that no great variations in range, mean, standard deviation or coefficient of variability were caused by environmental factors. The pedigree numbers show the relationship of the several inbred strains to each other.

From these tables it can be seen that both height of plant and length of ear have been reduced, but in different degrees in different lines. In some strains reduction in height amounts to 40 inches and in length of ear to 3.5 inches. The reduction in

Frequency distribution of height of plant of a non-inbred variety of maize and inbred strains derived from it.

Height of plant in inches.																		N.	A.	S. D.	C. V.
8.5	63.5	68.5	73.5	78.5	83.5	88.5	93.5	98.5	103.5	108.5	113.5	118.5	123.5	128.5	133.5	138.5	143.5				
..	..	..	..	..	..	..	1	4	5	7	11	9	6	3	2	..	..	48	114.0±.91	9.40±.64	8.24±.56
..	..	..	..	..	..	..	2	2	4	4	10	8	11	13	5	1	..	60	119.2±.91	10.50±.64	8.81±.54
..	..	..	..	..	..	..	1	1	4	15	8	9	6	7	3	0	1	55	116.3±.90	10.05±.65	8.64±.55
..	..	..	..	..	..	..	1	0	4	7	8	6	10	8	3	3	..	50	119.3±.98	10.30±.69	8.63±.58
..	..	..	..	..	..	..	5	7	17	33	37	32	33	31	13	4	1	213	117.3±.48	10.33±.34	8.81±.29
..	..	..	..	..	..	4	11	30	11	..	..	..	..	..	..	..	..	56	97.8±.36	4.05±.26	4.14±.26
..	..	..	..	..	..	5	22	24	10	..	..	..	..	..	..	..	..	61	96.7±.37	4.25±.26	4.40±.27
..	..	..	..	2	2	9	16	14	3	..	..	..	..	..	..	..	..	46	93.6±.57	5.75±.41	6.14±.43
..	..	..	..	..	..	..	7	11	26	8	4	..	..	..	..	..	..	56	102.7±.47	5.25±.33	5.11±.32
1	3	8	3	11	20	6	..	..	..	..	..	..	..	..	..	..	..	52	78.5±.71	7.65±.51	9.75±.64
2	3	1	6	9	12	19	6	..	..	..	..	..	..	..	..	..	..	58	82.2±.77	8.75±.55	10.64±.67
..	..	..	1	3	3	18	26	2	..	..	..	..	..	..	..	..	..	53	90.2±.46	4.95±.33	5.49±.36
..	..	1	1	1	7	16	7	5	..	..	..	..	..	..	..	..	..	38	88.7±.70	6.45±.50	7.27±.56
..	1	1	8	9	18	13	3	1	..	..	..	..	..	..	..	..	..	54	82.6±.61	6.65±.43	8.05±.52
..	..	1	1	2	8	8	18	11	2	..	..	..	..	..	..	..	..	51	91.2±.68	7.25±.48	7.95±.52
2	2	2	14	26	12	1	..	..	..	..	..	..	..	..	..	..	..	59	77.0±.52	5.95±.37	7.73±.48
..	..	..	10	22	25	3	..	..	..	..	..	..	..	..	..	..	..	60	80.3±.35	4.05±.25	5.04±.31

TABLE 5. FREQUENCY DISTRIBUTION OF LENGTH OF EAR OF A NON-INBRED VARIETY OF MAIZE AND INBRED STRAINS DERIVED FROM IT.

Pedigree number	Length of ear in inches											N.	A.	S. D.	C. V.
	2	3	4	5	6	7	8	9	10	11	12				
1 (Original	..	..	..	7	12	20	13	3	1	0	1	57	7.0±.12	1.33±.08	19.00±1.24
1 non-inbred	..	..	2	6	9	12	11	7	3	1	..	51	7.2±.15	1.61±.11	22.36±1.55
1 Leaming	..	..	2	1	7	19	19	9	3	1	..	61	7.6±.11	1.31±.08	17.24±1.08
1 variety)	..	..	1	1	4	14	18	18	3	..	..	59	7.9±.10	1.20±.08	15.19± .96
Total............	..	..	5	15	32	65	61	37	10	2	1	228	7.5±.06	1.43±.05	19.07± .63
1-6-1-3-4-4-4-2-4-4-3	..	1	5	8	16	29	..	..	..	..	..	59	6.1±.09	1.05±.07	17.17±1.18
1-6-1-3-4-4-4-2-4-1-2	..	..	2	7	29	19	1	..	..	..	..	58	6.2±.07	.81±.05	13.06± .82
1-6-1-3-4-4-4-2-5-5-1	..	2	7	11	7	8	10	1	..	..	..	46	6.0±.16	1.57±.11	26.17±1.95
1-6-1-3-4-4-4-2-5-3-1	..	..	3	5	6	25	16	1	..	..	..	56	6.9±.10	1.12±.07	16.23±1.05
1-7-1-1-1-4-7-5-2-6-1	..	7	27	28	..	..	..	..	..	..	..	62	4.3±.06	.67±.04	15.58± .96
1-7-1-1-1-4-7-5-2-1-1	3	5	25	22	1	..	..	..	..	..	..	56	4.2±.08	.84±.06	20.00±1.31
1-7-1-1-1-4-7-5-4-7-2	5	10	24	18	..	..	..	..	..	..	..	57	4.0±.08	.91±.06	22.75±1.51
1-7-1-1-1-4-7-5-4-5-2	..	9	12	14	1	..	..	..	..	..	..	36	4.2±.09	.83±.07	19.76±1.62
1-7-1-2-2-9-2-1-1-4-1	1	3	10	11	14	4	..	..	..	..	..	43	5.1±.12	1.19±.09	23.33±1.77
1-7-1-2-2-9-2-1-1-1-3	..	1	6	15	18	2	..	..	..	..	..	42	5.3±.09	.85±.07	16.04±1.20
1-9-1-2-4-6-7-5-6-4	..	..	3	8	25	19	..	..	..	..	..	55	6.1±.08	.84±.06	13.77± .90
1-9-1-2-4-6-7-5-3-3	..	..	1	9	44	5	..	..	..	..	..	59	5.9±.05	.55±.04	9.32± .58

TABLE 6. FREQUENCY DISTRIBUTION OF THE NUMBER OF NODES OF A NON-INBRED VARIETY OF MAIZE AND INBRED STRAINS DERIVED FROM IT.

Pedigree number	Number of nodes											N.	A.	S. D.	C. V.
	8	9	10	11	12	13	14	15	16	17	18				
1 (Original	..	..	..	..	4	12	19	22	1	3	1	62	14.3±.10	1.21±.07	8.46±.51
1 non-inbred	..	..	..	2	9	15	15	11	5	0	1	58	13.8±.12	1.40±.09	10.14±.63
1 Leaming	..	..	..	1	0	9	26	15	3	4	1	59	14.4±.10	1.20±.08	8.33±.52
1 variety)	..	..	2	2	10	13	19	12	2	5	1	66	13.8±.14	1.66±.10	12.03±.71
Total	..	..	2	5	23	49	79	60	11	12	4	245	14.1±.06	1.42±.04	10.07±.31
1-6-1-3-4-4-4-2-4-4-3	..	..	..	2	25	28	3	..	..	..	..	58	12.7±.06	.65±.04	5.12±.32
1-6-1-3-4-4-4-2-4-1-2	..	..	1	30	30	..	..	..	..	..	..	61	11.5±.05	.53±.04	4.61±.28
1-6-1-3-4-4-4-2-5-5-1	..	..	..	6	24	13	6	..	..	..	..	49	12.4±.08	.86±.06	6.94±.47
1-6-1-3-4-4-4-2-5-3-1	..	1	0	6	34	18	..	..	..	..	..	59	12.2±.06	.73±.05	5.98±.37
1-7-1-1-1-4-7-5-2-6-1	..	1	2	11	35	5	..	..	..	..	..	54	11.8±.07	.74±.05	6.27±.40
1-7-1-1-1-4-7-5-2-1-1	1	1	7	15	21	14	..	..	..	..	..	59	11.6±.10	1.12±.07	9.66±.60
1-7-1-1-1-4-7-5-4-7-2	..	..	1	5	34	14	3	..	..	..	..	57	12.2±.07	.76±.05	6.23±.39
1-7-1-1-1-4-7-5-4-5-2	..	..	1	2	13	18	5	1	..	..	..	40	12.7±.10	.95±.08	7.48±.56
1-7-1-2-2-9-2-1-1-4-1	..	1	1	14	18	21	1	..	..	..	..	56	12.1±.09	.96±.06	7.93±.50
1-7-1-2-2-9-2-1-1-1-3	..	..	1	1	12	23	15	..	..	..	..	52	13.0±.08	.88±.06	6.77±.45
1-9-1-2-4-6-7-5-6-4	..	..	..	3	15	27	13	1	..	..	..	59	12.9±.07	.86±.06	6.67±.41
1-9-1-2-4-6-7-5-3-3	..	..	..	2	6	39	13	..	..	..	..	60	13.1±.06	.67±.04	5.11±.31

TABLE 7. FREQUENCY DISTRIBUTION OF THE NUMBER OF ROWS OF GRAIN ON THE EAR OF A NON-INBRED VARIETY OF MAIZE AND INBRED STRAINS DERIVED FROM IT.

Pedigree number	Number of rows on the ear.								N.	A.	S. D.	C. V.
	12	14	16	18	20	22	24	26				
1 (Original	..	2	14	18	14	5	2	2	57	18.7±.23	2.64±.17	14.12±.91
1 non-inbred	..	1	15	21	8	3	3	..	51	18.2±.21	2.26±.15	12.42±.84
1 Leaming	2	6	7	19	17	7	2	..	60	18.4±.23	2.70±.17	14.67±.93
1 variety)	1	5	15	17	13	6	0	2	59	18.2±.24	2.76±.17	15.16±.96
Total............	3	14	51	75	52	21	7	4	227	18.4±.12	2.62±.08	14.22±.46
1-6-1-3-4-4-4-2-4-4-3	..	7	24	22	6	..	..	..	59	16.9±.14	1.66±.10	9.83±.61
1-6-1-3-4-4-4-2-4-1-2	..	12	42	4	..	..	..	..	58	15.7±.09	1.02±.06	6.48±.40
1-6-1-3-4-4-4-2-5-5-1	5	34	7	..	..	..	..	..	46	14.1±.10	1.02±.07	7.23±.51
1-6-1-3-4-4-4-2-5-3-1	6	37	13	..	..	..	..	..	56	14.3±.10	1.14±.07	7.96±.50
1-7-1-1-1-4-7-5-2-6-1	..	..	..	5	13	30	12	2	62	21.8±.16	1.84±.11	8.43±.51
1-7-1-1-1-4-7-5-2-1-1	..	..	..	6	14	14	19	3	56	22.0±.20	2.22±.14	10.10±.64
1-7-1-1-1-4-7-5-4-7-2	..	..	..	1	16	23	11	1	52	21.8±.15	1.63±.11	7.48±.49
1-7-1-1-1-4-7-5-4-5-2	..	..	1	10	13	11	1	..	36	20.1±.20	1.80±.14	8.94±.71
1-7-1-2-2-9-2-1-1-4-1	..	12	22	8	1	..	..	..	43	15.9±.15	1.49±.11	9.40±.68
1-7-1-2-2-9-2-1-1-1-3	..	12	20	10	..	..	..	..	42	15.9±.15	1.45±.10	9.06±.66
1-9-1-2-4-6-7-5-6-4	..	20	30	3	2	..	..	..	55	15.5±.13	1.43±.09	9.21±.59
1-9-1-2-4-6-7-5-3-3	..	19	40	..	..	..	..	..	59	15.4±.08	.94±.06	6.08±.38

length of ear is even more than it seems from this table because the variety contained plants which produced two ears of which the second is usually smaller than the first; whereas the inbred strains almost never produce more than one ear to a plant.

The number of nodes per plant is reduced but as compared to height and length of ear this reduction is very much less. In the number of rows of grain on the cob there is a reduction in some lines and an increase in others. These tables show in the clearest manner that inbreeding has a greater effect on some characters than on others, and that segregation of characters has occurred. Perhaps the most noticeable effect of inbreeding as shown by these tables is the reduction in variability as brought out by the range and statistical constants. This reduction in variability is most apparent in the characters which are the least reduced by inbreeding—number of nodes and number of rows of grain on the ear—although the low variability is also apparent in height and length of ear. In variability, also, there is a difference between different lines.

The variability in height and length of ear of the inbred strains is higher than it should be, owing to the fact that it was difficult to obtain a perfect stand of plants, on account of poor germination of the seeds of the inbred strains. The aim was to have three plants in a hill. From four to eight seeds were planted as far as a limited supply of seed would permit, and later, thinned to three plants. In spite of this precaution it was extremely difficult to get anything like a perfect stand, so missing plants were replanted as soon as possible. These replants, owing to their late start, never entirely caught up with the other plants and are shorter in height and have smaller ears in consequence. It is unfortunate that this practice was followed because it is believed that much more reliable results would have been obtained otherwise. On the other hand missing plants introduce another source of error—that of unequal opportunity to grow. Because there was abundant seed of the variety, and it germinated well, practically complete stands of these plants were obtained.

The reduction in variability is more apparent in the details of the structure of the plants and ears which cannot be expressed statistically. The beautiful uniformity of these plants in all characteristics at the present time is one of their most striking features. This can be seen fairly well in the accompanying photographs. (Plates I to V).

In view of this fact of great uniformity and constancy as a result of inbreeding one is astonished at the statement made recently by Stout ('16) in a discussion of the results obtained from inbreeding in maize by East and Hayes. Stout says (pp. 420–421):

"strains similar in homozygosity show widest variation indicative of spontaneous variation in natural vigor which is suggested that in such highly cultivated varieties such as corn extreme sporadic variations may be constantly occurring, a condition which is well shown by the numerous and well-known results of the ear to row test."

Several curious misconceptions are to be noted in this statement. In the first place, it has never been maintained by anyone to my knowledge that an equal number of generations of inbreeding produce an equal amount of homozgosity in different lines. Secondly, it has never been proposed that the degree of heterozygosity determined the form or structure of any organism, but that such a condition was accompanied by a stimulus to development which merely increased the expression of many hereditary factors. This stimulus is considered to be without any great effect *in itself* on variability. Granted that the inbred strains were equal in homozygosity at that time, that was no reason why they should be similar in vigor or in any other respect—in fact the expectation is exactly the reverse of this. With regard to "spontaneous" and "sporadic" variation these inbred strains show unmistakably that there is practically no sporadic or spontaneous variation, that the individuals making up an inbred strain are remarkably constant and uniform after some degree of homozygosity is obtained and that the diversity between different lines can be perfectly accounted for on the basis of segregation of characters. Also, in the following paragraphs in his paper Stout fails to see the distinction between crosses of diverse inbred lines and between crosses of non-inbred commercial varieties. Because Collins ('14) and Hayes ('14) failed to obtain increases in all crosses between commercial varieties of similar type Stout would question whether crossing in maize was ever beneficial. It is quite to be expected that there are many varieties already so widely crossed that further crossing does not result in greater heterozygosity, but may even reduce it. It is only in crosses between somewhat different varieties, like flint and dent (Jones and Hayes '17) or between varieties from

different geographical regions (Collins '10) that any great amount of heterosis in naturally widely crossed varieties is to be expected.

Although there has been a striking reduction in size of plant, general vegetative vigor and productiveness in these inbred strains of maize, and in comparison with non-inbred varieties the inbred plants are more difficult to grow, emphasis must be put on the fact that the plants are normal and healthy. The monstrosities which are common in every field of maize, such as the occurrence of seeds in the tassels, anthers in the ears, dwarf plants, completely sterile plants, mosaic and albino plants and other similar anomalies never appear in these inbred strains. Furthermore, in the details of the size, shape, structure and position of the tassels, leaves, stalks and ears, these inbred strains show the most striking uniformity. These minor details which characterize each of these groups of plants are difficult to describe but are perhaps the most noticeable feature about them. The stalks, the tassels or the ears of all of these four Leaming strains if mixed together could be separated without the slightest difficulty by anyone familiar with them. Some of the differences which characterize the ears of these four strains are shown in Plate Ib. It is to be noticed in this photograph that Nos. 1-7-1-2 and 1-7-1-1, which were originally from the same line, both have flat cobs. In one of them, however, it is colored, in the other uncolored. Other differences are to be seen in shape and color of seeds.

The segregation of row number accompanied by a reduction in variability in these two strains is shown in Table 8 and Fig II. Data previous to the third generation are not available but since then a noticeable change in average row number has taken place without any selection one way or the other. The variability of each line has decreased at the same time. Whether the increase in variability, after the eighth generation, has any significance is not known. It is possibly due to the fact that both lines have become irregular in row number so that the correct determination of the row number has been rendered more difficult in the later generations. Also the number of plants grown in the generations from the 7th to the 10th are much too few to base accurate conclusions upon. The sharp increase in average row number and decrease in variability in the 8th generation are probably due to the unusually favorable growing conditions of that year.

TABLE 8. REDUCTION IN VARIABILITY AND SEGREGATION OF EAR ROW NUMBER IN INBRED STRAINS OF MAIZE.

Year grown.	Generations selfed.	Pedigree number.	Number of rows of grain on the ear. 12	14	16	18	20	22	24	26	28	N.	A.	C. V.
1908	3	1-7-1-1	3	3	4	6	27	7	4	1	2	57	19.7±.30	17.00±1.10
1908	3	1-7-1-2	..	..	..	..	..	..	..	..	..	..	....	....
1910	4	1-7-1-1-1	..	2	5	11	17	19	6	1	..	61	20.2±.22	12.67± .78
1910	4	1-7-1-2-2	..	..	2	8	14	9	5	1	..	39	20.5±.25	11.20± .86
1911	5	1-7-1-1-1-4	..	..	3	4	10	16	4	1	..	38	20.9±.25	10.92± .85
1911	5	1-7-1-2-2-9	..	..	14	29	21	1	..	..	..	65	18.3±.13	8.34± .49
1912	6	1-7-1-1-1-4-7	..	..	..	..	..	..	..	..	..	..	....	....
1912	6	1-7-1-2-2-9-2	..	..	..	..	..	..	..	..	..	..	....	....
1913	7	1-7-1-1-1-4-7-5	..	..	1	3	5	1	..	..	..	10	19.2±.34	8.33±1.26
1913	7	1-7-1-2-2-9-2-1	..	4	12	2	..	..	..	..	..	18	15.8±.18	7.16± .80
1914	8	1-7-1-1-1-4-7-5-4	..	..	..	1	9	16	6	..	..	32	21.7±.18	4.72± .40
1914	8	1-7-1-2-2-9-2-1-1	..	..	17	20	6	..	..	..	..	43	17.5±.14	7.83± .57
1915	9	1-7-1-1-1-4-7-5-4-5	..	..	..	1	14	4	2	..	..	21	20.7±.21	6.90± .72
1915	9	1-7-1-2-2-9-2-1-1-4	..	6	16	7	..	..	..	..	..	29	16.1±.17	8.33± .74
1916	10	1-7-1-1-1-4-7-5-4-5-2	..	..	1	10	13	11	1	..	..	36	20.1±.20	8.94± .71
1916	10	1-7-1-2-2-9-2-1-1-4-3	..	12	22	8	1	..	..	..	..	43	15.9±.15	9.40± .68
1917	11	1-7-1-1-1-4-7-5-4-5-2-1	..	..	3	20	43	22	7	..	..	95	20.2±.13	9.15± .45
1917	11	1-7-1-2-2-9-2-1-1-4-3-1	3	23	45	22	2	..	..	..	..	95	15.9±.11	10.39± .51

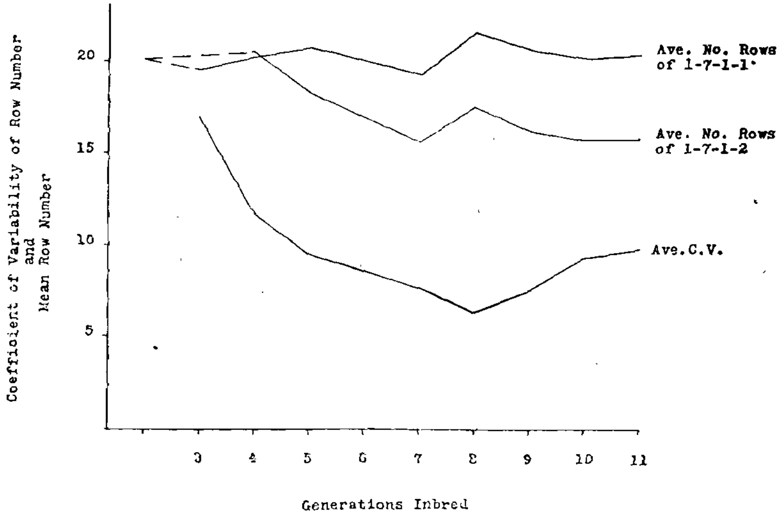

Figure II. The reduction in variability and segregation of number of rows of grain on the ear in selfed strains of maize.

East and Hayes ('12) have noted many characters which are isolated from maize by inbreeding. In addition to these, several other characters have been isolated in this and in other material. One of these characters is a constant difference in shade of color of the foliage—some are dark green, others are light, yellowish green. Some strains are lacking in root development and never stand upright throughout the season. Some have a single-stalked unbranched tassel, while others are profusely branched. Some strains have peculiarly wrinkled or wavy leaves, particularly noticeable in the first leaves. Some strains produce a small proportion of connate seeds similar to those observed by Kempon ('13) in nearly every ear, while their occurrence has never been observed on other inbred lines derived from the same source. There are also marked differences in susceptibility to disease as will be shown later.

These illustrations are sufficient to demonstrate beyond doubt that by far the greatest amount of the fluctuating variability found among ordinary cross-fertilized plants is due to the segregation and re-combination of definite and constant hereditary factors. Many of these characters are seldom seen in continually cross-pollinated plants, and never are so many combined together.

This is due to the fact that they are recessive in nature and complex in mode of inheritance. The most significant feature about the characters which make their appearance in inbred strains is that none of them can be directly attributed to a loss of a physiological stimulation, although undoubtedly many of them may be modified by the vigor of the plant upon which they are borne. There is no one specific character common to all inbred strains but simply a general loss of vigor, a general loss of size and of productiveness accompanied by the appearance of specific characters more or less unfavorable to the plants' best development but these unfavorable characters are never all found in one inbred strain, nor is any one character common to all inbred strains.

Probably the most common result of inbreeding in maize is a reduction in the amount of pollen produced. This becomes apparent in a smaller size of all parts of the tassel, in shrunken and abortive anthers which are often never released by the glumes, with a consequent reduction in the amount of pollen available for fertilization. A normal corn plant should produce, on the average, anywhere from 1cc. to 10cc. or, in some cases, very much more pollen. I have made no actual measurements of the amounts produced. Many of the inbred strains, however, now produce only a small fraction of a cubic centimeter of pollen, and the production of this small amount is much affected by weather conditions, so that many strains, otherwise well developed and productive, are maintained with the utmost difficulty.

It has been my experience that self-sterility in corn is due to ovule or pollen abortion. Whenever pollen is obtained it seems to be able to function. Failures to obtain seed after pollen is applied are common, but are usually attributed to external factors. At least I know of no clear case where pollen is produced in which it fails to fertilize the ovules of plants which were capable of being fertilized by other pollen. Many cases of complete abortion of the pistillate part of the plant must occur, as many plants are lost through failure to set seed when good pollen has been applied. Just where the trouble lies is not always possible to detect. Undoubtedly, many cases of complete abortion of either staminate or pistillate functions, or both, occur during inbreeding, and the plants are eliminated for that reason.

Reduction in the amount of pollen produced is less serious than a reduction in the number of ovules, as a very small amount of

pollen suffices for fertilization when conditions are right. For that reason unconscious selection for good ovule production has been much more rigid than for pollen production. That is the reason, I believe, that more inbred strains now show a greater reduction in the staminate function than in the pistillate.

A significant feature of the effect of inbreeding upon sterility is that some inbred strains are perfectly normal in their production of pollen, and the amount of pollen produced is only a little less than non-inbred plants, owing to the reduced vigor and size of the plants which produce the tassels. Out of about twenty-five inbred strains carried through at least seven generations, three of them are perfectly normal in the structure and function of their staminate parts. One of the Leaming strains (No. 1–9) produces more pollen than many non-inbred varieties growing nearby. In every case, however, those plants which produce the best developed ears are the poorest producers of pollen, and those strains which produce abundant pollen have ears which are poorly developed. In other words, inbreeding is bringing about a tendency for maize to change from a functionally monoecious plant to a functionally dioecious plant although, morphologically, both staminate and pistillate parts are still present. This is illustrated in Plates VI, a and b, where tassels and ears of four of the inbred strains are shown.

Although no systematic selection has been practiced throughout the inbreeding experiment a great deal of selection upon many characters has been unavoidable as it is unavoidable in any inbreeding experiment. In maize, the difficulties of hand pollination result in the selection of plants whose staminate and pistillate parts are matured synchronously. Any great differences in this respect, particularly towards proterandry, would render self-fertilization difficult or impossible, as pollen, according to Andronescu ('15) has very short viability, which fact my own experience confirms. Of course, all plants which are weak, sterile, diseased or in any way abnormal tend to become eliminated wherever these causes reduce the chance of obtaining seed. This unconscious selection becomes more rigid as reduction in vigor and productiveness increases in the later generations of inbreeding. The small amount of seed produced by hand pollination, under the most favorable circumstances necessitates the using of the best

ears obtained for planting in order to have enough plants upon which to make any fair observations.

In every case inbreeding in maize has so far resulted in a reduction in size, vigor and productiveness. Some thirty or forty inbred strains have been observed, many of which are additional to the ones reported previously.

From the preceding statements in regard to the effect of inbreeding it can be said that this process produces types which differ in their power of development as follows:

1. Plants which cannot be perpetuated.

2. Plants which fail to complete normal development and can be propagated only with the greatest difficulty.

3. Plants which are perfectly normal but varying in the amount of growth they attain at maturity.

These normal inbred plants, so far obtained in maize, are not as a rule as large, vigorous or productive as the original cross-fertilized plants. It is theoretically possible to obtain such plants, which cannot be reduced in vigor in a homozygous condition as will be explained later. There is some evidence from the experiments of Darwin, that such plants have been obtained by inbreeding in other material, for example, in Ipomea and Mimulus. Selection will help to obtain these vigorous, unreduceable individuals but may not be fully effective in doing so. More or less unconscious selection is unavoidable in any inbreeding experiment.

These homozygous, normal, inbred strains, after the reduction in growth has ceased, are quite comparable to plants of a naturally self-fertilized species. Darwin found that self-pollination caused no reduction in vigor in Nicotiana, Pisum, Lathyrus, Phaseolus and other genera which are naturally self-fertilized to a large extent. Hayes and Jones ('17) have found similar results with the tomato. The only effect that inbreeding may have on such plants is merely to isolate pure lines, which are quite uniform among themselves, but may be diverse from one another, as shown by soy beans (Jones and Hayes ('17), but which show no reduction in vigor on continued artificial inbreeding. These results are perfectly in accord with Johannsen's genotype conception.

The Approach to Complete Homozygosity.

It now remains to be seen whether or not these inbred strains are reaching the limit of reduction. There are two ways of determining this, one is by growing two successive inbred generations side by side in the same year, the other is by crossing different plants within the same inbred strain.

In Table 9 the results from two successive generations grown side by side in the same year are compared. On the whole, an additional year of inbreeding after the sixth produces very little change. In Table 10 are given the height, yield and length of ear of selfed and sib-crossed plants which were grown in 1917. In 1916, in each of the strains of which figures are given in the table, some plants were selfed and some were crossed by another plant within the same strain. Since all the plants grown that year in any one strain came from one individual of the preceding generation, that generation is the significant one. In other words if the plant in that generation was homozygous, no increase of the sib-crossed plants over the selfed plants would be expected. The figures show that there is, on the whole, a slight increase in all the characters studied. The increase, however, is no greater in the cases where the common ancestor was inbred for seven generations than in the cases where it was inbred nine generations.

Shull ('11) compared sib-crosses with selfed plants in which the significant generation, as I understand it, was the fourth, and found that the crossed plants slightly excelled the selfed plants in height, number of rows on the ear and yield of grain. Similarly the $F_1 \times$ Sibs exceeded $F_1 \times$ self in yield, showing that in the fourth generation complete homozygosis had not been attained.

Whether or not complete homozygosis has been attained by some or all of the strains shown in Table 10 cannot be stated positively from the data given. In most cases the increase of the sib-crosses over the selfs is slight and probably of no significance as there are about an equal number of cases in which the reverse condition is shown. A few of the sib-crosses are, however, considerably greater than the selfs in all three characters and it may very well be that these strains have not attained the degree of homozygosity that the other strains have. More data are needed to establish this point with certainty as environmental factors which favored a certain plot in one character would also favor the other character as well.

TABLE 9. THE YIELD, HEIGHT AND LENGTH OF EAR OF TWO SUCCESSIVE INBRED GENERATIONS OF MAIZE BOTH GROWN SIDE BY SIDE IN THE SAME YEAR.

Pedigree number in the Nth generation	Generations compared		Yield: bu. per acre		Difference of (N+1) above N	Height of plant in inches		Difference of (N+1) above N	Length of ear in inches		Difference of (N+1) above N
	N	(N+1)	N	(N+1)		N	(N+1)		N	(N+1)	
65-8-2-2-6-5-2...	6	7	20.9	28.4	+ 7.5	53.3±.47	54.3±.41	+1.0± .62	5.4±.12	5.6±.09	+.2±.15
1-9-1-2-4-6-7-5-3..	8	9	28.8	30.5	+ 1.7	78.0±.57	80.3±.35	+2.3± .67	6.1±.08	5.9±.05	—.2±.09
1-7-1-2-2-9-2-1-1-4	9	10	26.3	20.0	— 6.3	83.9±.45	82.6±.61	—1.3± .76	5.4±.09	5.1±.12	—.3±.15
1-7-1-1-1-4-7-5-2-1	9	10	44.5	30.4	—14.1	84.8±.64	82.2±.77	—2.6±1.00	4.7±.07	4.2±.08	—.5±.11
1-7-1-1-1-4-7-5-4-5	9	10	....	....	......	88.5±.47	88.7±.70	+ .2± .84	4.4±.08	4.2±.09	—.2±.12
1-6-1-3-4-4-4-2-4-4	9	10	46.3	34.9	—11.4	100.6±.44	97.8±.36	—2.8± .57	6.2±.08	6.1±.09	—.1±.12
1-6-1-3-4-4-4-2-5-3	9	10	29.7	31.5	+ 1.8	98.2±.44	102.7±.47	+4.5± .64	6.4±.12	6.9±.10	+5. ±.16
Average.......			32.8	29.3	— 3.5	83.9	84.1	+ .2	5.5	5.4	—.1

TABLE 10. A COMPARISON OF THE HEIGHT, YIELD OF GRAIN AND LENGTH OF EAR OF SELFED STRAINS OF MAIZE WITH CROSSES BETWEEN INDIVIDUAL PLANTS WITHIN THE STRAINS.

Pedigree number	Significant generation	Height of plant in inches			Yield of grain in lbs. per plant			Length of ear in inches		
		Selfed strains	Sib crosses	Difference of sib crosses above selfed	Selfed strains	Sib crosses	Difference of sib crosses above selfed	Selfed strains	Sib crosses	Difference of sib crosses above selfed
10-3-7-3-9-7-5-1-1......	7	91.3±.58	93.4±.50	+2.1±.77	.25	.20	−.05	5.8±.02	6.4±.08	+.6±.08
10-3-7-3-9-7-5-4-2......	7	93.1±.53	94.2±.52	+1.1±.74	.26	.31	+.05	6.4±.06	6.1±.06	−.3±.08
10-4-8-3-5-3-4-8-2......	7	89.6±.53	87.1±.73	−2.5±.90	.31	.40	+.09	5.3±.07	5.0±.06	−.3±.09
10-4-8-3-5-3-4-5-2......	7	94.4±.56	95.9±.46	+1.5±.73	.38	.34	−.04	5.6±.06	5.9±.07	+.3±.09
1-9-1-2-4-6-7-5-6-2....	8	82.7±.29	81.6±.29	−1.1±.41	.24	.19	−.05	5.7±.06	4.9±.06	−.8±.08
1-9-1-2-4-6-7-5-3-2....	8	82.0±.33	84.2±.37	+2.2±.50	.20	.19	−.01	5.3±.05	5.7±.04	+.4±.06
1-6-1-3-4-4-4-2-4-4-2...	9	103.0±.42	109.4±.36	+6.4±.55	.33	.47	+.14	6.1±.08	6.9±.06	+.8±.10
1-6-1-3-4-4-4-2-4-1-3...	9	113.5±.37	109.9±.58	−3.6±.69	.44	.36	−.08	7.5±.04	7.2±.04	−.3±.06
1-6-1-3-4-4-4-2-5-3-2...	9	102.6±.53	103.4±.36	+ .8±.64	.40	.44	+.04	7.2±.06	7.3±.06	+.1±.08
1-6-1-3-4-4-4-2-5-5-2...	9	95.6±.50	95.2±.63	− .4±.80	.37	.40	+.03	6.9±.08	6.6±.10	−.3±.13
1-7-1-2-2-9-2-1-1-4-3...	9	83.8±.63	85.9±.57	+2.1±.85	.20	.26	+.06	4.5±.08	4.9±.07	+.4±.11
1-7-1-1-1-4-7-5-4-5-2...	9	83.8±.53	81.5±.60	−2.3±.80	.23	.24	+.01	3.9±.07	3.8±.05	−.1±.09
1-7-1-1-1-4-7-5-4-7-1...	9	76.1±.72	81.2±.53	+5.1±.89	.15	.23	+.08	3.5±.06	3.7±.05	+.2±.08
1-7-1-1-1-4-7-5-2-1-1...	9	78.7±.60	80.2±.55	+1.5±.81	.29	.19	−.10	4.1±.07	3.8±.06	−.3±.09
1-7-1-1-1-4-7-5-2-6-1...	9	75.6±.49	78.3±.55	+2.7±.74	.26	.35	+.09	3.8±.05	3.9±.06	+.1±.08
Average...............		89.7	90.8	+1.1	.29	.30	+.01	5.4	5.5	+.1

THE EFFECT OF HETEROZYGOSIS ON VEGETATIVE LUXURIANCE.

The most noticeable manifestation of heterosis in plants is a general increase in vegetative luxuriance. In maize this is particularly noticeable in increased height of plant, diameter of stalk, root development, length of ear and productiveness of grain (see Plates III, V, VII, VIII, IX, X and XII). In crosses between inbred strains of maize the amount of heterosis shown is inversely proportional to the degree of relationship as shown in Table 11. Montgomery ('12) has obtained similar results.

Some characters are much more affected by heterozygosis than others. In comparing Tables 12, 13 and 14 with Tables 15 and 16 it will be noticed that the yield of the crosses is increased 180 per cent., height is increased 27 per cent. and length of ear 29 per cent. over the average of their parental lines. On the other hand, the number of nodes per plant and number of rows of grain on the ear is increased only 6 and 5 per cent. respectively. In other words, heterozygosis does not increase the number of parts to anything like the extent that it increases the size of those parts. Those parts of the plants which are more or less indeterminate in size, like internodes, ears and seeds are augmented by crossing as the result of an increase in the rapidity and rate of cell division. The increase in size of parts is probably brought about by an increase in size of cells as well as an enormous increase in number of cells. Tupper and Bartlett ('16) have shown that *gigas* mutants in *Oenothera* have larger cells than the non-mutant type, so that a change in cell size may accompany a germinal change.

From Table 11 it will also be seen that some first generation hybrids may even surpass the original variety in yield, height or length of ear, although the comparison is rather unfair as the Leaming variety was not acclimatized as were the inbred strains. The return of vigor realized in the first generation crosses is often enormous, and the same is true of crossing inbred strains derived from totally different types of maize as is shown in Table 17.

Although there is an immediate and striking return to the vigorous condition of the non-inbred stock there is not a return in variability as shown in Tables 18, 19, 20, 21 and 22. The first generation crosses are no more variable than the inbred strains by which they are produced, in many cases less variable, and show striking differences when compared to the original stock. The coefficient of variability is entirely inadequate in bringing out

TABLE 11. THE DEGREE OF RELATIONSHIP AND THE AMOUNT OF HETEROSIS SHOWN BY INBRED STRAINS WHEN CROSSED.

Pedigree number	Significant generation	Yield bu. per acre	Increase above ave. yield of parents	Height inches	Increase above ave. height of parents	Length of ear inches	Increase above ave. length of parents
1-6-1-3-4-4-4-2-4-4-3	..	34.9	......	97.8± .36	......	6.1±.09	......
1-7-1-1-1-4-7-5-4-7-2	..	30.3	......	90.2± .46	......	4.0±.08	......
1-7-1-2-2-9-2-1-1-4-1	..	20.0	......	82.6± .61	......	5.1±.12	......
1-9-1-2-4-6-7-5-3-3	..	30.5	......	80.3± .35	......	5.9±.05	......
(1-6-1-3-4-4-4-2-4-1)×(1-6-1-3-4-4-4-2-4-4)	7	19.2	−15.7	88.4±1.12	− 9.4	5.3±.09	− .8
(1-7-1-1-1-4-7-5-2-6)×(1-7-1-1-1-4-7-5-2-1)	7	31.1	+ .8	79.2± .64	−11.0	4.5±.10	+ .5
(1-7-1-2-2-9-2-1-1-1)×(1-7-1-2-2-9-2-1-1-4)	7	23.9	+ 3.9	86.0± .63	+ 3.4	5.5±.10	+ .4
(1-9-1-2-4-6-7-5-3)×(1-9-1-2-4-6-7-5-6)	6	....	......	66.8± .48	−13.5	4.1±.10	−1.8
(1-6-1-3-4-4-4-2-4-4)×(1-6-1-3-4-4-4-2-5-5)	6	43.9	+ 9.0	103.4± .47	+ 5.6	6.7±.09	+ .6
(1-6-1-3-4-4-4-2-5-5)×(1-6-1-3-4-4-4-2-4-4)	6	....	......	98.1±1.12	+ .3	5.7±.15	− .4
(1-7-1-1-1-4-7-5-4-7)×(1-7-1-1-1-4-7-5-2-1)	6	17.5	−12.8	88.1± .74	− 2.1	4.7±.09	+ .7
(1-7-1-1-1-4-7-5-4-7)×(1-7-1-2-2-9-2-1-1-4)	1	70.9	+45.7	102.4± .44	+16.0	6.4±.12	+1.8
(1-7-1-2-2-9-2-1-1-1)×(1-7-1-1-1-4-7-5-2-6)	1	55.9	+30.7	103.1± .44	+16.7	6.3±.09	+1.7
(1-7-1-2-2-9-2-1-1-1)×(1-7-1-1-1-4-7-5-4-5)	1	58.4	+33.2	103.0± .50	+16.6	6.5±.08	+1.9
(1-6-1-3-4-4-4-2-4-1)×(1-7-1-2-2-9-2-1-1-1)	0	101.0	+73.5	121.9± .46	+31.7	7.9±.10	+2.3
(1-7-1-2-2-9-2-1-1-4)×(1-9-1-2-4-6-7-5-3)	0	82.1	+56.8	109.5± .76	+28.0	7.6±.13	+2.1
(1-9-1-2-4-6-7-5-3)×(1-6-1-3-4-4-4-2-4-1)	0	71.5	+38.8	110.5± .58	+21.4	7.6±.09	+1.6
1 Non-inbred variety	..	80.8	......	116.3± .90	......	7.6±.11	......

TABLE 12. THE EFFECT OF CROSSING INBRED STRAINS OF MAIZE AS SHOWN BY THE INCREASE IN THE YIELD OF GRAIN.

Pedigree number of strain—A	Yield of bushels per acre				Pedigree number of strain—B
	A	A×B	B×A	B	
1-6-1-3-4-4-4-2-4-4	34.9	99.1	99.9	30.3	1-7-1-1-1-4-7-5-4-7
1-6-1-3-4-4-4-2-4-4	34.9	112.9	....	37.4	1-7-1-1-1-4-7-5-2-6
1-6-1-3-4-4-4-2-4-4	34.9	82.4	....	30.7	1-9-1-2-4-6-7-5-6
1-6-1-3-4-4-4-2-4-1	31.9	101.0	....	18.3	1-7-1-2-2-9-2-1-1-1
1-6-1-3-4-4-4-2-5-5	16.8	88.1	84.4	30.3	1-7-1-1-1-4-7-5-4-7
1-6-1-3-4-4-4-2-5-5	16.8	103.2	106.7	20.0	1-7-1-2-2-9-2-1-1-4
1-6-1-3-4-4-4-2-5-5	16.8	91.0	....	30.7	1-9-1-2-4-6-7-5-6
1-6-1-3-4-4-4-2-5-3	31.5	94.8	....	30.4	1-7-1-1-1-4-7-5-2-1
1-9-1-2-4-6-7-5-3	30.5	63.9	....	31.5	1-6-1-3-4-4-4-2-5-3
1-9-1-2-4-6-7-5-3	30.5	71.5	....	31.9	1-6-1-3-4-4-4-2-4-1
1-9-1-2-4-6-7-5-3	30.5	58.0	....	30.4	1-7-1-1-1-4-7-5-2-1
1-9-1-2-4-6-7-5-3	30.5	52.5	100.5	18.9	1-7-1-1-1-4-7-5-4-5
1-9-1-2-4-6-7-5-3	30.5	59.6	82.1	20.0	1-7-1-2-2-9-2-1-1-4
1-9-1-2-4-6-7-5-6	30.7	66.3	....	18.3	1-7-1-2-2-9-2-1-1-1
1-7-1-2-2-9-2-1-1-4	20.0	84.9	....	34.9	1-6-1-3-4-4-4-2-4-4
1-7-1-1-1-4-7-5-2-6	37.4	40.5	....	16.8	1-6-1-3-4-4-4-2-5-5
1-7-1-1-1-4-7-5-2-1	30.4	59.4	....	31.9	1-6-1-3-4-4-4-2-4-1
Average..........	28.8	78.4		27.2	
Increase..........		50.4			
Percent increase....		180.00			

TABLE 13. THE EFFECT OF CROSSING INBRED STRAINS OF MAIZE AS SHOWN BY THE INCREASE IN THE HEIGHT OF PLANT.

Pedigree number of strain—A	Height of plant in inches				Pedigree number of strain—B
	A	A×B	B×A	B	
1-6-1-3-4-4-4-2-4-4	97.8±.36	117.3± .61	117.2±.44	90.2±.46	1-7-1-1-1-4-7-5-4-7
1-6-1-3-4-4-4-2-4-4	97.8±.36	117.6± .38	....	78.5±.71	1-7-1-1-1-4-7-5-2-6
1-6-1-3-4-4-4-2-4-4	97.8±.36	115.4± .56	....	77.0±.52	1-9-1-2-4-6-7-5-6
1-6-1-3-4-4-4-2-4-1	96.7±.37	121.9± .46	....	91.2±.68	1-7-1-2-2-9-2-1-1-1
1-6-1-3-4-4-4-2-5-5	93.6±.57	112.9±1.04	109.9± .77	90.2±.46	1-7-1-1-1-4-7-5-4-7
1-6-1-3-4-4-4-2-5-5	93.6±.57	116.1± .41	113.4± .51	82.6±.61	1-7-1-2-2-9-2-1-1-4
1-6-1-3-4-4-4-2-5-5	93.6±.57	113.8± .40	....	77.0±.52	1-9-1-2-4-6-7-5-6
1-6-1-3-4-4-4-2-5-3	102.7±.47	116.0± .42	....	82.2±.77	1-7-1-1-1-4-7-5-2-1
1-9-1-2-4-6-7-5-3	80.3±.35	111.1± .61	....	102.7±.47	1-6-1-3-4-4-4-2-5-3
1-9-1-2-4-6-7-5-3	80.3±.35	110.5± .58	....	96.7±.37	1-6-1-3-4-4-4-2-4-1
1-9-1-2-4-6-7-5-3	80.3±.35	109.2± .76	94.0±1.36	82.2±.77	1-7-1-1-1-4-7-5-2-1
1-9-1-2-4-6-7-5-3	80.3±.35	110.9± .60	114.1± .55	88.7±.70	1-7-1-1-1-4-7-5-4-5
1-9-1-2-4-6-7-5-3	80.3±.35	108.1± .50	109.5± .76	82.6±.61	1-7-1-2-2-9-2-1-1-4
1-9-1-2-4-6-7-5-6	77.0±.52	111.1± .58	....	91.2±.68	1-7-1-2-2-9-2-1-1-1
1-7-1-2-2-9-2-1-1-4	82.6±.61	114.9± .68	....	97.8±.36	1-6-1-3-4-4-4-2-4-4
1-7-1-1-1-4-7-5-2-6	78.5±.71	98.7± .78	....	93.6±.57	1-6-1-3-4-4-4-2-5-5
1-7-1-1-1-4-7-5-2-1	82.2±.77	105.2± .71	....	96.7±.37	1-6-1-3-4-4-4-2-4-1
Average..........	88.0	112.4		88.3	
Increase..........		24.2			
Percent increase....		27.44			

TABLE 14. THE EFFECT OF CROSSING INBRED STRAINS OF MAIZE AS SHOWN BY THE INCREASE IN THE LENGTH OF EAR.

Pedigree number of strain—A	Length of ear in inches				Pedigree number of strain—B
	A	A×B	B×A	B	
1-6-1-3-4-4-4-2-4-4	6.1±.09	7.1±.11	7.3±.10	4.0±.08	1-7-1-1-1-4-7-5-4-7
1-6-1-3-4-4-4-2-4-4	6.1±.09	7.5±.11	....	4.3±.06	1-7-1-1-1-4-7-5-2-6
1-6-1-3-4-4-4-2-4-4	6.1±.09	7.8±.08	....	6.1±.08	1-9-1-2-4-6-7-5-6
1-6-1-3-4-4-4-2-4-1	6.2±.07	7.9±.10	....	5.3±.09	1-7-1-2-2-9-2-1-1-1
1-6-1-3-4-4-4-2-5-5	6.0±.16	7.5±.12	6.8±.15	4.0±.08	1-7-1-1-1-4-7-5-4-7
1-6-1-3-4-4-4-2-5-5	6.0±.16	8.2±.08	8.0±.09	5.1±.12	1-7-1-2-2-9-2-1-1-4
1-6-1-3-4-4-4-2-5-5	6.0±.16	7.8±.08	....	6.1±.08	1-9-1-2-4-6-7-5-6
1-6-1-3-4-4-4-2-5-3	6.9±.10	7.6±.09	....	4.2±.08	1-7-1-1-1-4-7-5-2-1
1-9-1-2-4-6-7-5-3	5.9±.05	7.7±.09	....	6.9±.10	1-6-1-3-4-4-4-2-5-3
1-9-1-2-4-6-7-5-3	5.9±.05	7.6±.09	....	6.2±.07	1-6-1-3-4-4-4-2-4-1
1-9-1-2-4-6-7-5-3	5.9±.05	6.5±.12	5.5±.11	4.2±.08	1-7-1-1-1-4-7-5-2-1
1-9-1-2-4-6-7-5-3	5.9±.05	6.5±.10	7.6±.09	4.2±.09	1-7-1-1-1-4-7-5-4-5
1-9-1-2-4-6-7-5-3	5.9±.05	7.1±.12	7.6±.13	5.1±.12	1-7-1-2-2-9-2-1-1-4
1-9-1-2-4-6-7-5-6	6.1±.08	7.1±.11	....	5.3±.09	1-7-1-2-2-9-2-1-1-1
1-7-1-2-2-9-2-1-1-4	5.1±.12	7.6±.14	....	6.1±.09	1-6-1-3-4-4-4-2-4-4
1-7-1-1-1-4-7-5-2-6	4.3±.06	5.5±.12	....	6.0±.16	1-6-1-3-4-4-4-2-5-5
1-7-1-1-1-4-7-5-2-1	4.2±.08	6.0±.10	....	6.2±.07	1-6-1-3-4-4-4-2-4-1
Average...........	5.8	7.2		5.3	
Increase...........		1.6			
Percent increase....		28.57			

TABLE 15. THE EFFECT OF CROSSING INBRED STRAINS OF MAIZE AS SHOWN BY THE INCREASE IN THE NUMBER OF NODES.

Pedigree number of strain—A	Number of nodes				Pedigree number of strain—B
	A	A×B	B×A	B	
1-6-1-3-4-4-4-2-4-4	12.7±.06	13.6±.07	13.2±.07	12.2±.07	1-7-1-1-1-4-7-5-4-7
1-6-1-3-4-4-4-2-4-4	12.7±.06	13.3±.04	....	11.8±.07	1-7-1-1-1-4-7-5-2-6
1-6-1-3-4-4-4-2-4-4	12.7±.06	14.0±.05	....	12.9±.07	1-9-1-2-4-6-7-5-6
1-6-1-3-4-4-4-2-4-1	11.5±.05	14.0±.05	....	13.0±.08	1-7-1-2-2-9-2-1-1-1
1-6-1-3-4-4-4-2-5-5	12.4±.08	12.9±.08	13.2±.05	12.2±.07	1-7-1-1-1-4-7-5-4-7
1-6-1-3-4-4-4-2-5-5	12.4±.08	13.5±.06	13.1±.06	12.1±.09	1-7-1-2-2-9-2-1-1-4
1-6-1-3-4-4-4-2-5-5	12.4±.08	13.4±.06	....	12.9±.07	1-9-1-2-4-6-7-5-6
1-6-1-3-4-4-4-2-5-3	12.2±.06	13.3±.06	....	11.6±.10	1-7-1-1-1-4-7-5-2-1
1-9-1-2-4-6-7-5-3	13.1±.06	12.8±.06	....	12.2±.06	1-6-1-3-4-4-4-2-5-3
1-9-1-2-4-6-7-5-3	13.1±.06	12.9±.06	....	11.5±.05	1-6-1-3-4-4-4-2-4-3
1-9-1-2-4-6-7-5-3	13.1±.06	13.2±.06	12.5±.13	11.6±.10	1-7-1-1-1-4-7-5-2-1
1-9-1-2-4-6-7-5-3	13.1±.06	13.3±.06	14.0±.06	12.7±.10	1-7-1-1-1-4-7-5-4-5
1-9-1-2-4-6-7-5-3	13.1±.06	13.3±.07	13.7±.07	12.1±.09	1-7-1-2-2-9-2-1-1-4
1-9-1-2-4-6-7-5-6	12.9±.07	13.7±.06	....	13.0±.08	1-7-1-2-2-9-2-1-1-1
1-7-1-2-2-9-2-1-1-4	12.1±.09	13.6±.06	....	12.7±.06	1-6-1-3-4-4-4-2-4-4
1-7-1-1-1-4-7-5-2-6	11.8±.07	11.3±.07	....	12.4±.08	1-6-1-3-4-4-4-2-5-5
1-7-1-1-1-4-7-5-2-1	11.6±.10	12.6±.07	....	11.5±.05	1-6-1-3-4-4-4-2-4-1
Average...........	12.5	13.2		12.3	
Increase...........		.8			
Percent increase....		6.45			

TABLE 16. THE EFFECT OF CROSSING INBRED STRAINS OF MAIZE AS SHOWN BY THE INCREASE IN THE NUMBER OF ROWS OF GRAIN ON THE EAR.

Pedigree number of strain—A	Number of rows of grain on the ear: A	A×B	B×A	B	Pedigree number of strain—B
1-6-1-3-4-4-4-2-4-4	16.9±.14	19.5±.15	20.8±.15	21.8±.15	1-7-1-1-1-4-7-5-4-7
1-6-1-3-4-4-4-2-4-4	16.9±.14	19.5±.13	....	21.8±.16	1-7-1-1-1-4-7-5-2-6
1-6-1-3-4-4-4-2-4-4	16.9±.14	17.2±.13	....	15.5±.13	1-9-1-2-4-6-7-5-6
1-6-1-3-4-4-4-2-4-1	15.7±.09	18.4±.13	....	15.9±.15	1-7-1-2-2-9-2-1-1-1
1-6-1-3-4-4-4-2-5-5	14.1±.10	17.4±.11	18.3±.14	21.8±.15	1-7-1-1-1-4-7-5-4-7
1-6-1-3-4-4-4-2-5-5	14.1±.10	16.9±.10	18.2±.13	15.9±.15	1-7-1-2-2-9-2-1-1-4
1-6-1-3-4-4-4-2-5-5	14.1±.10	17.0±.10	....	15.5±.13	1-9-1-2-4-6-7-5-6
1-6-1-3-4-4-4-2-5-3	14.3±.10	19.4±.15	....	22.0±.20	1-7-1-1-1-4-7-5-2-1
1-9-1-2-4-6-7-5-3	15.4±.08	15.7±.11	....	14.3±.10	1-6-1-3-4-4-4-2-5-3
1-9-1-2-4-6-7-5-3	15.4±.08	16.7±.12	....	15.7±.09	1-6-1-3-4-4-4-2-4-1
1-9-1-2-4-6-7-5-3	15.4±.08	19.9±.20	18.7±.25	22.0±.20	1-7-1-1-1-4-7-5-2-1
1-9-1-2-4-6-7-5-3	15.4±.08	17.8±.14	19.0±.17	20.1±.20	1-7-1-1-1-4-7-5-4-5
1-9-1-2-4-6-7-5-3	15.4±.08	16.8±.17	16.2±.09	15.9±.15	1-7-1-2-2-9-2-1-1-4
1-9-1-2-4-6-7-5-6	15.5±.13	16.2±.14	....	15.9±.15	1-7-1-2-2-9-2-1-1-1
1-7-1-2-2-9-2-1-1-4	15.9±.15	19.3±.17	....	16.9±.14	1-6-1-3-4-4-4-2-4-4
1-7-1-1-1-4-7-5-2-6	21.8±.16	17.6±.14	....	14.1±.10	1-6-1-3-4-4-4-2-5-5
1-7-1-1-1-4-7-5-2-1	22.0±.20	19.8±.16	....	15.7±.09	1-6-1-3-4-4-4-2-4-1
Average...........	16.2	17.9		17.7	
Increase...........		.9			
Percent increase....		5.29			

TABLE 17. THE EFFECT OF CROSSING INBRED STRAINS DERIVED FROM DIFFERENT TYPES OF MAIZE.

Type	Pedigree number	Yield bu. per acre	Increase above ave. of parents	Height inches	Increase above ave. of parents	Length of ear inches	Increase above ave. of parents
Dent..........	1-6-1-3-4-4-4-2-4-4-3	34.9	....	97.8	....	6.1	....
Floury........	10-3-7-3-9-7-5-4-3.....	10.4	....	75.5	....	6.1	....
Flint..........	29-5-2-3-8...........	9.2	....	88.7	....	5.9	....
Pop...........	65-8-2-2-6-5-2-4......	28.4	....	54.3	....	5.6	....
Dent×Floury..	(1-6-1-3)×(10-3-7-3)..	90.4	+67.7	122.8	+36.1	9.1	+3.0
Dent×Flint...	(1-6-1-3)×(29-5-2-3)..	94.6	+72.5	117.5	+24.2	8.9	+2.9
Floury×Dent..	(10-3-7-3)×(1-6-1-3)..	43.3	+20.6	108.2	+21.5	7.4	+1.3
Floury×Flint..	(10-3-7-3)×(29-11-4-4)	61.1	+51.3	104.5	+22.4	9.7	+3.7
Flint×Dent...	(29-5-2-3)×(1-6-1-3)..	80.7	+58.6	115.7	+22.4	9.6	+3.6
Flint×Floury..	(29-5-2-3)×(10-3-7-3).	73.0	+63.2	112.9	+30.8	10.0	+4.0
Pop×Dent....	(65-8-2-2)×(1-6-1-3)..	73.1	+41.4	88.9	+12.8	7.2	+1.3
Pop×Flint....	(65-8-2-2)×(5-8-6-3)..	51.3	......	79.5	......	7.1	.....

TABLE 18. THE EFFECT OF CROSSING UPON VARIABILITY AS SHOWN BY THE HEIGHT OF PLANT.

Pedigree number of strain—A	Coefficient of variability of height				Pedigree number of strain—B
	A	A×B	B×A	B	
1-6-1-3-4-4-4-2-4-4	4.14±.26	6.10±.37	4.01±.26	5.49±.36	1-7-1-1-1-4-7-5-4-7
1-6-1-3-4-4-4-2-4-4	4.14±.26	3.74±.23	....	9.75±.64	1-7-1-1-1-4-7-5-2-6
1-6-1-3-4-4-4-2-4-4	4.14±.26	5.55±.34	....	7.73±.48	1-9-1-2-4-6-7-5-6
1-6-1-3-4-4-4-2-4-1	4.40±.27	4.22±.27	....	7.95±.52	1-7-1-2-2-9-2-1-1-1
1-6-1-3-4-4-4-2-5-5	6.14±.43	9.92±.66	7.32±.50	5.49±.36	1-7-1-1-1-4-7-5-4-7
1-6-1-3-4-4-4-2-5-5	6.14±.43	4.09±.25	5.20±.32	8.05±.52	1-7-1-2-2-9-2-1-1-4
1-6-1-3-4-4-4-2-5-5	6.14±.43	4.00±.25	....	7.73±.48	1-9-1-2-4-6-7-5-6
1-6-1-3-4-4-4-2-5-3	5.11±.32	4.05±.26	....	10.64±.67	1-7-1-1-1-4-7-5-2-1
1-9-1-2-4-6-7-5-3	5.04±.31	6.66±.39	....	5.11±.32	1-6-1-3-4-4-4-2-5-3
1-9-1-2-4-6-7-5-3	5.04±.31	6.15±.38	....	4.40±.27	1-6-1-3-4-4-4-2-4-1
1-9-1-2-4-6-7-5-3	5.04±.31	7.78±.49	12.61±1.04	10.64±.67	1-7-1-1-1-4-7-5-2-1
1-9-1-2-4-6-7-5-3	5.04±.31	6.18±.38	5.48±.34	7.27±.56	1-7-1-1-1-4-7-5-4-5
1-9-1-2-4-6-7-5-3	5.04±.31	5.27±.33	7.94±.49	8.05±.52	1-7-1-2-2-9-2-1-1-4
1-9-1-2-4-6-7-5-6	7.73±.48	6.26±.38	....	7.95±.52	1-7-1-2-2-9-2-1-1-1
1-7-1-2-2-9-2-1-1-4	8.05±.52	6.27±.41	....	4.14±.26	1-6-1-3-4-4-4-2-4-4
1-7-1-1-1-4-7-5-2-6	9.75±.64	8.81±.56	....	6.14±.43	1-6-1-3-4-4-4-2-5-5
1-7-1-1-1-4-7-5-2-1	10.64±.67	7.41±.47	....	4.40±.27	1-6-1-3-4-4-4-2-4-1
Average...........	5.98	6.03		7.11	

TABLE 19. THE EFFECT OF CROSSING UPON VARIABILITY AS SHOWN BY THE LENGTH OF EAR.

Pedigree number of strain—A	Coefficient of variability of length of ear				Pedigree number of strain—B
	A	A×B	B×A	B	
1-6-1-3-4-4-4-2-4-4	17.17±1.18	19.86±1.18	16.99±1.05	22.75±1.51	1-7-1-1-1-4-7-5-4-7
1-6-1-3-4-4-4-2-4-4	17.17±1.18	17.33±1.02	....	15.58± .96	1-7-1-1-1-4-7-5-2-6
1-6-1-3-4-4-4-2-4-4	17.17±1.18	11.92± .74	....	13.77± .90	1-9-1-2-4-6-7-5-6
1-6-1-3-4-4-4-2-4-1	13.06± .82	14.94± .93	....	16.04±1.20	1-7-1-2-2-9-2-1-1-1
1-6-1-3-4-4-4-2-5-5	26.17±1.95	17.73±1.11	25.88±1.65	22.75±1.51	1-7-1-1-1-4-7-5-4-7
1-6-1-3-4-4-4-2-5-5	26.17±1.95	11.71± .72	12.37± .77	23.33±1.77	1-7-1-2-2-9-2-1-1-4
1-6-1-3-4-4-4-2-5-5	26.17±1.95	12.44± .76	....	13.77± .90	1-9-1-2-4-6-7-5-6
1-6-1-3-4-4-4-2-5-3	16.23±1.05	13.55± .85	....	20.00±1.31	1-7-1-1-1-4-7-5-2-1
1-9-1-2-4-6-7-5-3	9.32± .58	14.16± .87	....	16.23±1.05	1-6-1-3-4-4-4-2-5-3
1-9-1-2-4-6-7-5-3	9.32± .58	13.82± .84	....	13.06± .82	1-6-1-3-4-4-4-2-4-1
1-9-1-2-4-6-7-5-3	9.32± .58	20.46±1.36	15.45±1.47	20.00±1.31	1-7-1-1-1-4-7-5-2-1
1-9-1-2-4-6-7-5-3	9.32± .58	17.69±1.15	13.55± .83	19.76±1.62	1-7-1-1-1-4-7-5-4-5
1-9-1-2-4-6-7-5-3	9.32± .58	18.87±1.23	20.26±1.26	23.33±1.77	1-7-1-2-2-9-2-1-1-4
1-9-1-2-4-6-7-5-6	13.77± .90	18.73±1.16	....	16.04±1.20	1-7-1-2-2-9-2-1-1-1
1-7-1-2-2-9-2-1-1-4	23.33±1.77	19.87±1.30	....	17.17±1.18	1-6-1-3-4-4-4-2-4-4
1-7-1-1-1-4-7-5-2-6	15.58± .96	24.91±1.66	....	26.17±1.95	1-6-1-3-4-4-4-2-5-5
1-7-1-1-1-4-7-5-2-1	20.00±1.31	18.83±1.21	....	13.06± .82	1-6-1-3-4-4-4-2-4-1
Average...........	16.39	16.87		18.40	

TABLE 20. THE EFFECT OF CROSSING UPON VARIABILITY AS SHOWN BY THE NUMBER OF NODES.

Pedigree number of strain—A	Coefficient of variability of number of nodes				Pedigree number of strain—B
	A	A×B	B×A	B	
1-6-1-3-4-4-4-2-4-4	5.12±.32	5.88±.36	5.91±.37	6.23±.39	1-7-1-1-1-4-7-5-4-7
1-6-1-3-4-4-4-2-4-4	5.12±.32	3.68±.22	....	6.27±.40	1-7-1-1-1-4-7-5-2-6
1-6-1-3-4-4-4-2-4-4	5.12±.32	4.50±.27	....	6.67±.41	1-9-1-2-4-6-7-5-6
1-6-1-3-4-4-4-2-4-1	4.61±.28	4.00±.25	....	6.77±.45	1-7-1-2-2-9-2-1-1-1
1-6-1-3-4-4-4-2-5-5	6.94±.47	6.82±.43	4.09±.27	6.23±.39	1-7-1-1-1-4-7-5-4-7
1-6-1-3-4-4-4-2-5-5	6.94±.47	5.48±.32	5.34±.33	7.93±.50	1-7-1-2-2-9-2-1-1-4
1-6-1-3-4-4-4-2-5-5	6.94±.47	5.67±.35	....	6.67±.41	1-9-1-2-4-6-7-5-6
1-6-1-3-4-4-4-2-5-3	5.98±.37	5.19±.32	....	9.66±.60	1-7-1-1-1-4-7-5-2-1
1-9-1-2-4-6-7-5-3	5.11±.31	5.47±.33	....	5.98±.37	1-6-1-3-4-4-4-2-5-3
1-9-1-2-4-6-7-5-3	5.11±.31	5.66±.35	....	4.61±.28	1-6-1-3-4-4-4-2-4-1
1-9-1-2-4-6-7-5-3	5.11±.31	5.53±.34	8.72±.73	9.66±.60	1-7-1-1-1-4-7-5-2-1
1-9-1-2-4-6-7-5-3	5.11±.31	5.41±.34	4.93±.30	7.48±.56	1-7-1-1-1-4-7-5-4-5
1-9-1-2-4-6-7-5-3	5.11±.31	5.86±.36	6.20±.38	7.93±.50	1-7-1-2-2-9-2-1-1-4
1-9-1-2-4-6-7-5-6	6.67±.41	5.62±.34	....	6.77±.45	1-7-1-2-2-9-2-1-1-1
1-7-1-2-2-9-2-1-1-4	7.93±.50	5.15±.33	....	5.12±.32	1-6-1-3-4-4-4-2-4-4
1-7-1-1-1-4-7-5-2-6	6.27±.40	7.61±.47	....	6.94±.47	1-6-1-3-4-4-4-2-5-5
1-7-1-1-1-4-7-5-2-1	9.66±.60	6.67±.42	....	4.61±.28	1-6-1-3-4-4-4-2-4-1
Average..........	6.05	5.54		6.80	

TABLE 21. THE EFFECT OF CROSSING UPON VARIABILITY AS SHOWN BY THE NUMBER OF ROWS OF GRAIN ON THE EAR.

Pedigree number of strain—A	Coefficient of variability of number of rows				Pedigree number of strain—B
	A	A×B	B×A	B	
1-6-1-3-4-4-4-2-4-4	9.83±.61	9.73±.55	8.68±.52	7.48±.49	1-7-1-1-1-4-7-5-4-7
1-6-1-3-4-4-4-2-4-4	9.83±.61	8.50±.48	....	8.43±.51	1-7-1-1-1-4-7-5-2-6
1-6-1-3-4-4-4-2-4-4	9.83±.61	8.79±.54	....	9.21±.59	1-9-1-2-4-6-7-5-6
1-6-1-3-4-4-4-2-4-1	6.48±.40	7.96±.49	....	9.06±.66	1-7-1-2-2-9-2-1-1-1
1-6-1-3-4-4-4-2-5-5	7.23±.51	7.31±.45	9.24±.55	7.48±.49	1-7-1-1-1-4-7-5-4-7
1-6-1-3-4-4-4-2-5-5	7.23±.51	6.62±.40	8.11±.49	9.40±.68	1-7-1-2-2-9-2-1-1-4
1-6-1-3-4-4-4-2-5-5	7.23±.51	6.60±.40	....	9.21±.59	1-9-1-2-4-6-7-5-6
1-6-1-3-4-4-4-2-5-3	7.96±.50	8.92±.55	....	10.10±.64	1-7-1-1-1-4-7-5-2-1
1-9-1-2-4-6-7-5-3	6.08±.38	8.00±.48	....	7.96±.50	1-6-1-3-4-4-4-2-5-3
1-9-1-2-4-6-7-5-3	6.08±.38	8.36±.50	....	6.48±.40	1-6-1-3-4-4-4-2-4-1
1-9-1-2-4-6-7-5-3	6.08±.38	11.11±.72	10.32±.98	10.10±.64	1-7-1-1-1-4-7-5-2-1
1-9-1-2-4-6-7-5-3	6.08±.38	8.92±.56	10.62±.65	8.94±.71	1-7-1-1-1-4-7-5-4-5
1-9-1-2-4-6-7-5-3	6.08±.38	11.35±.72	7.02±.42	9.40±.68	1-7-1-2-2-9-2-1-1-4
1-9-1-2-4-6-7-5-6	9.21±.59	10.42±.63	....	9.05±.66	1-7-1-2-2-9-2-1-1-1
1-7-1-2-2-9-2-1-1-4	9.40±.68	9.68±.63	....	9.83±.61	1-6-1-3-4-4-4-2-4-4
1-7-1-1-1-4-7-5-2-6	8.43±.51	8.75±.56	....	7.23±.51	1-6-1-3-4-4-4-2-5-5
1-7-1-1-1-4-7-5-2-1	10.10±.64	8.84±.56	....	6.48±.40	1-6-1-3-4-4-4-2-4-1
Average..........	7.83	8.82		8.58	

UENCY DISTRIBUTION OF HEIGHT OF PLANT OF A NON-INBRED VARIETY OF MAIZE, OF SEVERAL INBRED STRAINS DERIVED FROM THIS VARIETY AND FIRST GENERATION CROSSES BETWEEN THESE INBRED STRAINS.

number	Height of plant in inches																	N.	A.	C. V.
	63.5	68.5	73.5	78.5	83.5	88.5	93.5	98.5	103.5	108.5	113.5	118.5	123.5	128.5	133.5	138.5	143.5			
....	..	..	..	..	..	..	1	1	4	15	8	9	6	7	3	0	1	55	116.3 ± .90	8.64 ± .55
....	..	..	..	..	..	4	11	30	11	..	..	..	..	..	..	..	..	56	97.8 ± .36	4.14 ± .26
....	..	..	1	3	3	18	26	2	..	..	..	..	..	..	..	..	..	53	90.2 ± .46	5.49 ± .36
....	1	1	8	9	18	13	3	1	..	..	..	..	..	..	..	..	..	54	82.6 ± .61	8.05 ± .52
....	..	..	10	22	25	3	..	..	..	..	..	..	..	..	..	..	..	60	80.3 ± .35	5.04 ± .31
(1-7-1-1-1-4-7-5-4-7).	..	..	..	..	..	..	2	2	1	2	9	27	17	1	..	..	..	61	117.3 ± .61	6.10 ± .37
(1-7-1-2-2-9-2-1-1-1).	..	..	..	..	..	..	1	0	0	1	2	10	39	4	..	..	..	57	121.9 ± .46	4.22 ± .27
(1-9-1-2-4-6-7-5-6)...	..	..	..	..	1	0	0	1	2	3	20	26	6	..	..	..	..	59	115.4 ± .56	5.55 ± .34
(1-6-1-3-4-4-4-2-5-5).	..	1	0	2	3	3	5	11	20	8	..	..	..	..	..	..	..	56	98.7 ± .78	8.81 ± .56
(1-9-1-2-4-6-7-5-3)...	..	..	..	..	..	..	..	2	6	6	19	19	6	..	..	..	..	58	114.1 ± .55	5.48 ± .34
(1-6-1-3-4-4-4-2-4-4).	..	..	..	..	..	..	2	0	2	9	13	18	4	3	..	..	..	51	114.9 ± .68	6.27 ± .41
(1-9-1-2-4-6-7-5-3)...	..	..	1	0	1	0	1	3	10	14	23	6	..	..	..	..	..	59	109.5 ± .76	7.94 ± .49
-6-1-3-4-4-4-2-5-3)...	..	..	..	..	..	3	2	0	5	16	23	17	..	..	..	..	..	66	111.1 ± .61	6.66 ± .39
-7-1-1-1-4-7-5-2-1)...	..	..	..	..	..	2	2	9	5	8	18	12	1	..	..	..	..	57	109.2 ± .76	7.78 ± .49
-7-1-2-2-9-2-1-1-4)...	..	..	..	..	..	2	1	4	7	25	19	1	..	..	..	..	..	59	108.1 ± .50	5.27 ± .33

the beautiful uniformity of these crosses between inbred strains. In every respect each plant is a replica of the other. A collection of such vigorous and uniform maize plants in the field is a novel sight (see Plates IIIb and Vb).

Shull ('14) has pointed out that vigorous plants may be less susceptible to the effect of the environment than weaker types and that first generation hybrids, between uniform strains, may even show a reduction in variability.

The results obtained show this quite noticeably. Particularly was this true of several F_1's grown between their parental strains in a demonstration plot on rich low ground. During both seasons (1916–'17) when they were grown on this piece of ground, the weather was especially unfavorable when the plants were just starting, the ground being saturated with water most of the time. The germination in the selfed lines was extremely poor and many plants which did grow were stunted, and remained so throughout the season and never attained full height nor did they produce either tassels or ears. The variability of height, in these plants, was far greater than in many non-inbred varieties. Several plants, when killed by frost in the fall, were not over 30 inches tall while the average height of this strain is from 80 to 85 inches. The hybrids also had a poorer start than non-inbred varieties grown on the same ground on account of the small seed, but were able to overcome their handicap and in a few weeks were quite uniform. At the end of the season the difference in variability between the F_1 on the one hand and the inbred strains and the varieties on the other was striking. These plants were not used in the statistical work given here. The crosses and parents which were used and which were apparently quite uniform show a slight reduction in variability, in the number of nodes and in height in the F_1's as compared with their parents as can be seen in Tables 18 and 20. As Shull also pointed out, the variability of some characters may be increased by heterosis. This is shown in number of rows on the ear. The inbred strains rarely or never produce a second ear. The vigorous hybrids almost always do, and as the data have been obtained by counting all the ears gathered from a plot, the variability of the crosses, as shown in Tables 19 and 21, consequently seems greater than it really is as the second ear on nearly every plant is smaller and contains a fewer number of rows.

Although reciprocal crosses are on the whole nearly equal in respect to the degree in which heterosis is shown, there is some evidence, from Table 12, that this is not always so. Observations from the crosses in the field showed clearly that those in which strain Number 1-6 was used as the female, were usually more vigorous and productive than the others. In Table 23 the yields of all the crosses and reciprocal crosses (from 1 to 4 of each) having the same parental races are averaged. An average of all those

TABLE 23. YIELD OF RECIPROCAL CROSSES AMONG INBRED STRAINS OF MAIZE.

(All crosses grown 1916. Yield given as bushels per acre.)

	1-9-1-2 ♀	1-7-1-2 ♀	1-7-1-1 ♀	1-6-1-3 ♀	Average ♂
1-9-1-2 ♂		82.1	100.5	86.7	89.8
1-7-1-2 ♂	63.0		70.9	103.6	79.2
1-7-1-1 ♂	55.3	57.2		98.7	70.4
1-6-1-3 ♂	67.7	95.8	92.2		85.2
Average ♀	62.0	78.4	87.9	96.3	
Yield selfed:					
(1917)	31.8	37.6	42.3	46.2	
(1916)	30.6	19.2	32.7	32.8	
Ave. weight of seed-cg.	16.6	27.9	19.9	34.1	

crosses in which each strain was used as the male and in which each was used as the female parent shows some striking results. Those crosses on the whole in which strain Number 1–9 was used as the female gave the lowest yield. Those crosses in which strain Number 1–6 was used as the female are clearly the most productive. Strain Number 1–6 is the one which has the largest seeds and in which the pistillate inflorescence is the best developed of the four strains and at the expense of the staminate inflorescence.

Strain Number 1–9 is just the reverse of this. It is the best developed of all the inbred strains in its staminate inflorescence, always producing abundant pollen, but has the smallest seeds, and is one of the poorest in the development of its pistillate inflorescence. Approximately a uniform stand of plants was obtained in all these crossed plots. They were all grown side by side in the same field in the same year.* There seems, therefore, to be a marked correlation in the development of the pistillate inflorescence between the mother and her hybrid progeny. The high yield of the crosses in which Number 1–9 was used as the male is due to the fact that its average yield was not pulled down by the low yielding crosses in which it was used as a female. The crosses in which 1–7–1–1 and 1–7–1–2 were used cannot be compared fairly with the other two because these two strains are more closely related. This correlation bears a close relationship with the size and development of the seed which produces first generation hybrid plant. The seeds of strain 1–9 are the poorest developed, those of Number 1–6 are the best. Hence, the plants of crosses (1–6) x (1–9) have a better start than the plants of the reciprocal cross. This assumption is borne out by the fact that the second generation starting from large fully developed seeds grown on vigorous F_1 plants are larger at the start than the F_1 plants grown from small, poorly developed seeds produced on inbred plants. This is shown in Fig. III and Plate IX. The second generation, however, is surpassed by the first before the end of the season, as shown in Fig. III and Plate X. Somewhat similar results have been obtained by Castle ('16) in guinea-pigs. F_2 animals, out of vigorous F_1 females, are larger at the start than either parent but do not surpass the F_1 individuals as in this case. It will be seen from this that in plants or animals which are reduced by inbreeding, the F_1 is handicapped in comparison with the F_2 and the immediately following generations.

It is not certain that the differences between reciprocal crosses can be accounted for on a purely nutritional basis. There is the possibility of unequal germinal reactions with different cytoplasms.

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*The crossed strains were not grown between their inbred parental strains as was the case in the yields reported in U. S. Dept. of Agric., B. P. I. Bull. 243. This accounts in part for the extraordinarily large yields obtained at that time.

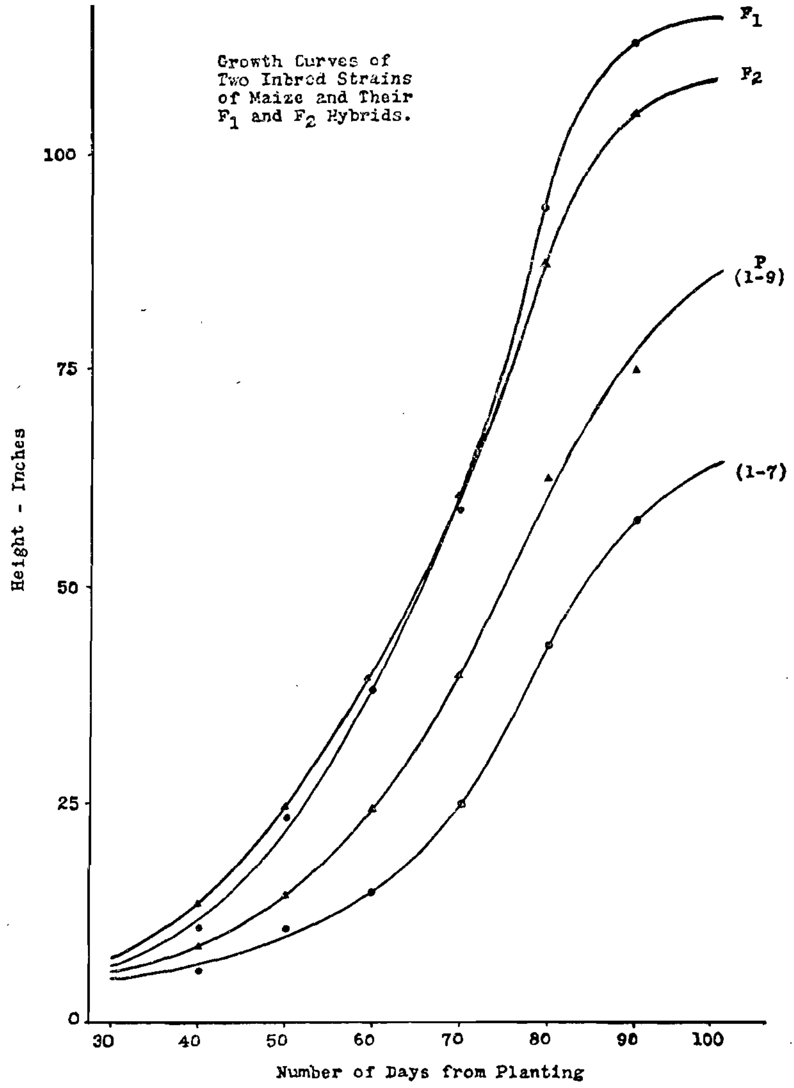

Figure III. Growth curves of two inbred strains of maize and their first and second generation hybrids.

The Value of Inbreeding in Plant and Animal Improvement.

These inbreeding and crossbreeding experiments on corn have considerable theoretical importance in the improvement of cultivated plants and domesticated animals. We have seen that inbreeding results in the elimination of abnormal, pathological and undesirable characters in general. This result has been obtained with a loss of size, vigor and productiveness. When these inbred strains are crossed, however, vigor and productiveness are returned in increased amount due to the uniform excellence of the individuals freed from undesirable characters. In this way a new variety or breed can be synthesized from the purified inbred strains of an old stock. A great sacrifice is thus made to attain a great good. Of course such a variety would have to be fixed by selection during a number of generations. The common practice of crossing in animals and plants already extremely heterozygous in order to obtain further improvement is like trying to solve a picture puzzle in the dark. It is only by resolving a naturally crossed species into homozygous types by inbreeding that it can be best analyzed and its desirable characters most surely selected for the recreation of an improved type.

The practical value of inbreeding has long been recognized by the breeders of domesticated animals. To gain uniformity and the highest expression of certain desirable characters they often practice inbreeding until the vigor of the breed is frequently impaired. From the results obtained with maize it seems that they stop just before the greatest good is to be accomplished. What if vigor is lost? It can always be regained immediately by crossing. There is no surer way of eliminating undesirable characters and discovering the best that there is in a stock than by a process of rigid inbreeding followed by subsequent testing in different crosses. This is not offered as a practical plan of procedure for the improvement of animals. It is merely intended to call attention to a principle which has probably not been used to its fullest extent. It may be that many domesticated breeds of animals cannot endure inbreeding to the extent that maize can. The cost of obtaining such pure types might very easily be prohibitive. The writer believes, however, that the splitting up of a breed of animals or a naturally crossed variety of plants by long continued inbreeding of the closest kind possible followed by the recombination of the most desirable inbred types, obtained in sufficient numbers to insure

that nothing of value present in the stock at the start, is lost, is a valuable, practicable method of improvement in many animals and plants. According to this method a variety or breed would be re-created and then continued in a naturally crossed condition just as it was before. The value of this procedure as a method for plant improvement is now being tested. It is, of course, a long time proposition and one that must be carried on extensively to promise results.

With a few plants which are easily crossed it is possible to utilize hybrid vigor to the fullest extent by growing only first generation plants. Attention has been repeatedly called to this method of increasing the productiveness, particularly of maize and tomatoes. The greatest amount of hybrid vigor is shown in maize when the plants have been previously inbred. Unfortunately, when the inbreeding is carried on for several generations the reduction in the vigor of the resulting plants is so great that the small size and low vitality of the seeds borne on inbred plants seriously handicaps the hybrid plants grown from these seeds as just shown. So what is gained by an increased amount of heterosis may be partly lost by the poor start which the plants have. This handicap, in comparison with normally-crossed varieties, the F_1 may not be able to overcome entirely even though it is far more uniform and free from barren, mal-formed and otherwise undesirable plants—factors which count heavily in maximum production.

A way to overcome this handicap suggests itself which is to cross two vigorous first generation hybrids whose composition is such that the resulting cross will not be less heterozygous than either parent and, therefore, theoretically no less vigorous and productive. This is easily accomplished by taking four distinct inbred strains which are of such a composition that a cross between any two of them gives a vigorous product. Now by crossing two of these strains to make one first generation hybrid, and at the same time crossing the other two to make another, and then by combining the two first generation hybrids there should be no reduction in heterozygosity. These doubly crossed plants, however, starting from large seeds produced on large, vigorous hybrid plants would be freed from the handicap which their parents had and although somewhat less uniform should be more productive. While it may be out of place to say anything about this method

until it has been thoroughly tested it is a method which is more promising than the plan originally advocated because by this method crossed seed for general field planting is produced much more abundantly than when non-vigorous inbred strains are crossed.

The Effect of Heterozygosis upon Endosperm Development and Selective Fertilization.

Together with the increase in size of other parts of the plant there is also an appreciable increase in the size and weight of seeds of maize immediately resulting from cross-pollination. This has been shown clearly by Collins and Kempton ('13) by pollinating several ears of maize with a mixture of the plant's own pollen and that of a different variety. Roberts ('12), Carrier ('13) and Wolfe ('15) have also shown that in maize the endosperm is increased by crossing. The writer ('18) has shown that this increase in endosperm development appears even more strikingly in reciprocal crosses between different inbred strains of maize. At that time reciprocal crosses had not been obtained between different individual plants. In Table 24 are given the distributions of the weights of the seeds shown in Plate XIa. Two plants were pollinated with a mixture of pollen obtained from these same two plants. One of the plants had white seeds and the other yellow and the selfed and crossed seeds on each ear could be easily distinguished. The same pollen mixture was also applied to a third plant of an inbred strain different from either of the other two but more nearly related to one than to the other. The average difference in weights between the selfed and crossed seeds on each ear are large. The two out-crossed lots of seeds on the third ear do not differ as greatly but the heavier seeds resulted from the wider cross.

Table 25 gives a number of averages of the weights of seeds from similar pairs of ears each having selfed and reciprocally crossed seeds. In every case there is a noticeable increase in weight as the result of crossing. In Table 26 the weights of the out-crossed seeds resulting from some of the same pollen mixtures are given. Here again the heavier seeds are those which have resulted from the wider cross. A and C are two inbred strains derived from one variety at the start while B is derived from a

TABLE 24. THE IMMEDIATE EFFECT OF POLLINATION ON THE WEIGHT OF SEEDS OF MAIZE AS SHOWN BY SELFED, RECIPROCALLY CROSSED AND OUT-CROSSED SEEDS OBTAINED FROM A MIXTURE OF POLLEN FROM TWO PLANTS OF TWO DIFFERENT INBRED STRAINS.

Type	Color of seeds	Weight of seeds in centigrams																N.	A.	Difference
		12.3	14.2	16.1	18.0	19.9	21.8	23.7	25.6	27.5	29.4	31.3	33.2	35.1	37.0	38.9	40.8			
A	White..................	..	1	0	0	0	6	7	35	66	60	10	..	..	..	..	..	185	27.6±.11	....
A×B	Light yellow............	..	..	..	..	..	1	2	4	6	15	35	87	25	3	..	..	178	32.3±.12	4.7±.16
B×A	Light yellow............	..	1	0	1	5	5	9	11	15	18	19	18	8	11	6	1	128	29.9±.31	6.1±.34
B	Dark yellow............	..	2	2	3	9	41	49	39	19	4	0	0	0	1	..	..	169	23.8±.15	....
C×A	White..................	1	2	10	17	27	16	14	8	3	..	..	..	..	..	..	..	98	20.5±.22	....
C×B	Light yellow............	..	..	..	1	13	57	56	26	5	1	..	..	..	..	..	..	159	23.1±.10	2.6±.24

TABLE 25. THE IMMEDIATE EFFECT OF POLLINATION UPON THE WEIGHT OF SEEDS OF MAIZE. (Selfed and reciprocally crossed seeds from the same ears.)

Pollen mixture number	Pedigree number of parent plant—A	A Selfed	A×B Crossed	B×A Crossed	B Selfed	Pedigree number of parent plant—B
		White	Light yellow		Yellow	
1	21-3-13-9-7-57-1	27.0	32.1	30.3	22.3	14-10-30-4-3-7-11-4
2	21-3-13-9-7-57-2	20.3	21.9	25.2	21.4	14-10-30-4-3-7-11-3
3	21-3-13-9-7-57-3	26.0	31.1	30.9	22.5	14-10-30-4-3-7-11-10
4	21-3-13-9-7-57-5	22.2	24.3	31.4	25.3	14-10-30-4-3-7-11-2
5	21-3-13-9-7-57-7	26.9	31.1	35.2	28.3	14-10-30-4-4-2-7-6
6	21-3-13-9-7-57-10	27.8	32.4	29.9	23.7	14-10-30-4-3-7-11-1
7	21-3-13-9-7-57-14	28.0	30.3	39.4	29.5	14-10-30-4-4-2-7-3
8	21-3-13-9-7-57-20	30.9	35.5	21.6	21.1	14-10-30-6-11-3-11-3
9	21-3-13-9-7-57-24	28.5	33.0	29.1	25.5	14-10-4-6-4-7-8-5
10	21-3-13-9-7-57-25	24.6	29.7	36.6	30.1	14-10-4-6-16-2-12-8
11	21-3-13-9-7-57-29	32.4	38.4	24.1	19.3	14-10-30-4-3-7-11-7
12	21-3-13-9-7-57-31	14.7	17.3	24.3	20.5	14-10-30-4-3-7-11-8
13	21-3-13-9-7-57-33	16.5	18.9	23.6	18.5	14-10-30-4-3-7-11-9
14	21-3-13-9-7-57-35	19.2	23.6	31.3	25.5	14-10-30-4-3-7-11-18
15	21-3-13-9-7-57-36	22.3	25.1	36.4	28.9	14-10-30-4-4-2-7-14
16	21-3-13-9-7-57-43	20.6	22.7	34.5	27.3	14-10-30-4-4-2-7-2
Average		24.2	28.0	30.2	24.4	
Increase of crossed above selfed			3.8	5.8		
Percent increase			15.70	23.77		

TABLE 26. THE IMMEDIATE EFFECT OF POLLINATION UPON THE WEIGHT OF SEEDS OF MAIZE. (Out-crossed seeds resulting from some of the same pollen mixtures used in *Table* 25.)

Pedigree number of parent plant—C	Pollen mixture number	Average weight of seeds in centigrams: Cross C×A		Cross C×B	
20A-8-5-35-8	1		20.5		24.5
20A-8-5-35-3	2		19.7		23.7
20A-8-5-35-4	3		25.4		25.0
20A-8-5-35-11	6		20.3		22.9
20A-8-5-35-24	8		27.3		27.5
20A-8-5-35-26	9		25.9		27.7
20A-8-5-35-6	13		20.2		20.1
20A-8-5-35-13	16	20.1		25.8	
20A-8-5-35-15	16	23.9		27.5	
20A-8-5-35-18	16	21.6		20.9	
20A-8-5-35-21	16	20.2		18.9	
20A-8-5-35-30	16	21.7		21.2	
20A-8-5-35-37	16	21.6		21.0	
		Ave. 21.5	21.5	22.6	22.6
Average			22.7		24.3
Increase of (C×B) over (C×A)					1.6
Percent increase					7.05

different variety. All the data taken together clearly show that an increase in endosperm development in maize is one of the common manifestations of heterosis.

Since the crossed seeds receive a noticeable impetus in development it seemed quite likely that the foreign pollen might be more efficient in fertilizing than the self pollen and hence a greater number of crossed seed than selfed would be produced. Such is not the case, however, as an examination of a large amount of data has shown.

In performing the mixed pollinations no attempt was made to have more than approximately equal quantities of pollen. It is impossible to get a mixture of equal quantities of functional pollen because it varies so in respect to viability. Since the same mixture of pollen was applied to both plants the ratio of the seeds resulting from "yellow" pollen to the seeds produced by the "white" pollen should be the same on both ears. Thus if there were no selective fertilization the percent of white seeds on one ear plus the percent of dark yellow seeds on the other, selfed seeds in both cases, should equal the sum of the percents of the crossed seeds on each ear. An excess of crossed seeds would then indicate a selective fertilization in favor of the crossed pollen. As a small excess of selfed seeds was obtained any selective fertilization in favor of the foreign pollen certainly did not take place.

The numbers of the crossed and selfed seeds, of which the weights are given in Tables 25 and 26, together with a large amount of similar data are not given here for fear of unduly burdening this publication with tables but they show, on the whole, a small excess of selfed seeds instead of crossed seeds. The results of an experiment designed to test this point in a somewhat different way are given in Table 27. Here instead of taking a mixture of pollen from two plants of two different strains a large amount of pollen was collected from an approximately equal number of plants of two long inbred and exceedingly uniform strains of maize. The two lots of pollen were sifted to obtain pure pollen and equal quantities of each were carefully measured out, thoroughly mixed together and applied to a number of ears of each of the two strains which furnished the pollen—A and B— and to a third strain—C—distinct from either. Although the tassels were bagged on the same day and the pollen collected two days later and equal quantities of each taken there

TABLE 27. THE NUMBER AND PROPORTION OF SELFED, RECIPROCALLY CROSSED AND OUT-CROSSED SEEDS OBTAINED BY MEANS OF A MIXTURE OF POLLEN FROM TWO DIFFERENT INBRED STRAINS OF MAIZE.

	Plant number	Selfed seeds from yellow pollen	Crossed seeds from white pollen	Plant number	Crossed seeds from yellow pollen	Selfed seeds from white pollen	Plant number	Out-crossed seeds from yellow pollen	Out-crossed seeds from white pollen
		A	A×B		B×A	B		C×A	C×B
	A1	317	1	B1	319	5	C1	361	10
	A2	189	2	B2	224	9	C2	429	15
	A3	270	7	B3	369	10	C3	421	13
	A4	389	8	B4	348	26	C4	445	1
	A5	332	8	B5	330	6	. .	. . .	. .
	A6	260	1	. .	. . .	. .	. .	. . .	. .
Total number		1757	27		1590	56		1656	39
Actual proportion, percent		98.49	1.51		96.60	3.40		97.70	2.30
Closest perfect proportion, percent		97.545	2.455		97.545	2.455		97.545	2.455
Deviation		+.945	−.945		−.945	+.945		+.155	−.155
Probable error		±.195			±.301			±.246	
Ave. wt. per seed in centigrams		13.8	18.1		18.0	15.7		20.5	20.3
Increase		. .	4.3		2.3	. .		.2	. .
Percent increase			30.4		14.6			1.0	

Note: The yellow seeded plants A = 1-9-1-2-4-6-7-5-6-2-1; the white seeded plants B = 10-4-8-3-5-3-4-8-2-1 and the yellow seeded plants C = 1-6-1-3-4-4-4-2-4-4-2-5. All seeds resulted from one mixture of pollen obtained from approximately equal numbers of plants of the two strains—A and B.

was not equal quantities of functional pollen as the number of seeds given in Table 27 show. The great inequality of functional pollen may have been due to the fact that the pollen of the B strain was more moist and tended to aggregate into a flocculent mass while the pollen of the other was perfectly dry and each grain remained separated from the others. For this reason it was difficult to measure the two lots of pollen equally and the dry pollen clustered about the fine lumps of moist pollen when the two kinds were mixed and was probably first to gain access to the stigmas. The difference between the two kinds of pollen was not due to any external differences, as far as could be seen, and indicate differences in the rate of maturing after shedding.

Whatever may be the cause of the great difference in fertilizing power this does not effect the point under investigation. However different the pollen may be, the seeds resulting from "yellow" pollen should be in the same ratio to the seeds resulting from the "white" pollen on one ear as the ratio of the same two kinds of seeds on the other ear within the limits of the error of random sampling if there is no selective fertilization one way or the other. And both these ratios should be the same as the third ratio obtained when this same mixture of pollen is used to produce seeds on a plant of a different variety of maize. Let us see what the figures given in Table 27 show. Of the reciprocal crosses and selfs the proportion, expressed as percent, is as follows:

Seed color carried by pollen............	Yellow		White		Yellow		White
Type of Seeds........................	Selfed		Crossed		Crossed		Selfed
Actual proportion obtained.....	98.490	:	1.510	::	96.600	:	3.400
Closest perfect proportion......	97.545	:	2.455	::	97.545	:	2.455
Deviation	+.945		−.945		−.945		+.945

The deviation from the closest perfect proportion is in favor of the selfed seeds. This theoretical ratio agrees very closely with the actual ratio obtained from the out-crossed seeds as shown in Table 27 although there is considerable difference in the results from the different ears. Letting S stand for selfed and C for crossed the probable error of the determination $\frac{S}{S+C}$ is $\pm \frac{.6745}{S+C} \sqrt{\frac{(S)(C)}{S+C}}$. The fraction $\frac{S}{S+C}$ gives the percent of selfed seeds and the probable error is stated as percent. Likewise the fraction $\frac{C}{S+C}$ gives the percent of

crossed seeds and the probable error is the same as for the percent of selfed seeds.

This same experiment was repeated with about the same number of plants with the result of a similar excess of selfed seeds greater than would be expected from the probable error on the assumption that there is no selective fertilization. Does this mean that there is a selective fertilization in favor of a plant's own pollen and that the plant discriminates against foreign pollen even though the seeds resulting from that foreign pollen are greatly increased in size, weight, viability and the rate of growth of the ensuing plants? Unless there has been a constant error in classifying the seeds this seems to be the necessary conclusion to be drawn from the results so far given by maize. A sufficient number of plants will be grown from this seed to determine definately whether or not there has been any error in the separation of the seeds so that this question can be answered with a high degree of certainty.

In the meantime there is little doubt but that there is no great selective fertilization in favor of cross-pollination, if any, however much that cross-pollination may benefit the resulting seeds and the plants grown from them. If this is true crossing is without effect until the zygote is formed at the time of the union of the male and female nuclei.

In a consideration of selective fertilization it should be remembered that there are two different conditions which may be included in the term selective fertilization. One may be said to be the selection of different germ-plasms; the other the selection of different cytoplasms. For example a heterozygous plant produces pollen grains with different germinal compositions but all enclosed in the same cytoplasm. On the other hand pollen from different plants may differ in the nature of the cytoplasm as well as in hereditary factors carried in the nuclear material. East and Park ('18) have demonstrated that in tobacco there is no selective fertilization between gametes coming from one plant although the pollen grains differ in factors which determine fertility or sterility of the ensuing plants. The case is quite similar to that of the shape of pollen grains in peas which may be either all round or all cylindrical according to the germinal composition of the sporophyte which produced them and not according to the factors which they carry. Where pollen grains differ both

was not equal quantities of functional pollen as the number of seeds given in Table 27 show. The great inequality of functional pollen may have been due to the fact that the pollen of the B strain was more moist and tended to aggregate into a flocculent mass while the pollen of the other was perfectly dry and each grain remained separated from the others. For this reason it was difficult to measure the two lots of pollen equally and the dry pollen clustered about the fine lumps of moist pollen when the two kinds were mixed and was probably first to gain access to the stigmas. The difference between the two kinds of pollen was not due to any external differences, as far as could be seen, and indicate differences in the rate of maturing after shedding.

Whatever may be the cause of the great difference in fertilizing power this does not effect the point under investigation. However different the pollen may be, the seeds resulting from "yellow" pollen should be in the same ratio to the seeds resulting from the "white" pollen on one ear as the ratio of the same two kinds of seeds on the other ear within the limits of the error of random sampling if there is no selective fertilization one way or the other. And both these ratios should be the same as the third ratio obtained when this same mixture of pollen is used to produce seeds on a plant of a different variety of maize. Let us see what the figures given in Table 27 show. Of the reciprocal crosses and selfs the proportion, expressed as percent, is as follows:

Seed color carried by pollen	Yellow		White		Yellow		White
Type of Seeds	Selfed		Crossed		Crossed		Selfed
Actual proportion obtained	98.490	:	1.510	::	96.600	:	3.400
Closest perfect proportion	97.545	:	2.455	::	97.545	:	2.455
Deviation	+.945		−.945		−.945		+.945

The deviation from the closest perfect proportion is in favor of the selfed seeds. This theoretical ratio agrees very closely with the actual ratio obtained from the out-crossed seeds as shown in Table 27 although there is considerable difference in the results from the different ears. Letting S stand for selfed and C for crossed the probable error of the determination $\frac{S}{S+C}$ is $\pm \frac{.6745}{S+C}\sqrt{\frac{(S)(C)}{S+C}}$. The fraction $\frac{S}{S+C}$ gives the percent of selfed seeds and the probable error is stated as percent. Likewise the fraction $\frac{C}{S+C}$ gives the percent of

crossed seeds and the probable error is the same as for the percent of selfed seeds.

This same experiment was repeated with about the same number of plants with the result of a similar excess of selfed seeds greater than would be expected from the probable error on the assumption that there is no selective fertilization. Does this mean that there is a selective fertilization in favor of a plant's own pollen and that the plant discriminates against foreign pollen even though the seeds resulting from that foreign pollen are greatly increased in size, weight, viability and the rate of growth of the ensuing plants? Unless there has been a constant error in classifying the seeds this seems to be the necessary conclusion to be drawn from the results so far given by maize. A sufficient number of plants will be grown from this seed to determine definately whether or not there has been any error in the separation of the seeds so that this question can be answered with a high degree of certainty.

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in the factors which they carry and in the plants from which they come, as is the case with these experiments with maize, the conditions are quite different. It would not be surprising that there should be selective fertilization in one case and not in the other. East and Park have shown that a tobacco plant which was self-sterile, pollinated with a mixture of its own and pollen from another plant with which it was fertile, gave all crossed seeds—a maximum of selective fertilization.

Darwin (" Cross and Self Fertilization ") found that there was a selective fertilization in favor of foreign pollen in different plants. Many of Darwin's experiments, however, were made in such a way as to be open to doubt whether or not he really did obtain such an effect. His experiments, in applying foreign pollen sometime after self-pollination had taken place, in which he obtained in some cases many or all apparently crossed progeny, are open to other interpretations. The purity of the plants pollinated was not known. External conditions influencing fertilization were not guarded against. Taken as they stand, however, his experiments with *Mimulus*, *Iberis*, *Brassica*, *Raphinus*, *Allium* and *Primula* do indicate that in these plants there may be a selective fertilization in favor of foreign pollen. It is to be expected that plants which show partial self-incompatibility would show selective fertilization when a mixture of self and foreign pollen was applied. In maize, however, as mentioned before, the sterility shown is in the nature of pollen and ovule abortion, and whenever well formed pollen is produced it seems to be able to fertilize equally any plants if not too distinct in type. A distinction should be made, then, between self-fertile plants and self-sterile plants when dealing with selective fertilization.

Hyde ('14) has shown clearly that in Drosophila both males and females of inbred lines are more productive of offspring when mated to an individual of a different line than when mated to one of their own. Both males and females, therefore, produce more functional gametes than are utilized when individuals of the same inbred lines are paired. Hence a female, impregnated with a mixture of two kinds of spermatozoa from the same and from different lines would produce more hybrid progeny than inbred progeny even if equal quantities of both types of spermatozoa were available for fertilization. In other words there would be selective fertilization in favor of cross-fertilization.

Whether or not there may be a similar condition in other animals I do not know. Even in Drosophila, fertilization by the two types of sperm may take place equally, and a greater proportion of close-fertilized eggs, than cross-fertilized, fail to hatch, due to lesser vigor or lethal factors. In Hyde's experiments the type of fertilization had no marked effect on the number of eggs laid, only on the percentage which hatched.

In maize, and possibly all plants which show no self-incompatibility, the fact seems clear that crossing is wholly without effect until the fertilization process is completed.

Although there is apparently no effect of crossing in maize until the zygote is formed, such an effect is apparent immediately afterwards. In addition to the increase in endosperm development there is also an increase in the vigor of the embryo. Whether or not the size of the embryo in the seed is increased has not been actually determined, other than by inspection, but it undoubtedly is, along with the endosperm. When crossed and selfed seeds from the same ear, grown on a plant which has been inbred previously for several generations, are planted a striking difference is soon apparent. The crossed seedlings appear from one to two days before the selfed seedlings and may be two or three inches above ground before any of the selfed plants begin to appear. (See Plate XIb). From then on the superiority of the crossed over the selfed plants increases rapidly as shown by the curves in Figure III.

THE EFFECT OF HETEROZYGOSIS UPON LONGEVITY, HARDINESS AND VIABILITY.

An increased longevity, viability and endurance against unfavorable climatic conditions have been frequently noted in hybrids. Kölreuter and Wiegmann both mention this fact. Gärtner in his book "Bastarderzeugung im Pflanzenreich" devotes considerable attention to this feature. Under the heading "Ausdauer und Lebenstenacität der Bastardpflanzen" he makes the following statements.

" There is certainly no essential difference between annual and biennial plants and between these and perennials in regard to their longevity; for it is not seldom that different individuals of the same species have a longer life at times as, for example, *Draba verna,* which has annual and

biennial forms; the longevity of a plant furnishes thereby no specific differences but signifies at most a variability as Prof. W. D. I. Koch has shown. However, in hybrids this difference deserves special consideration. In most hybrids an increased longevity and greater endurance can be observed as compared with their parental races even if they come into bloom a year earlier. The union of a annual, herbaceous female plant with a perennial, shrubby species through hybridization does not shorten the life cycle of the forthcoming hybrid as the union of *Hyoscyamus agrestis* with *niger*, *Nicotiana rustica* with *perennis*, *Calceolaria plantaginea* with *rugosa* shows, and so also in reciprocal crosses when the perennial species furnishes the seed and the annual species supplies the pollen, as *Nicotiana glauca* with *Langsdorfii*, *Dianthus caryophyllus* with *chinensis*, *Malva sylvestris* with *Mauritiana* or biennials with perennials and reciprocally as *Digitalis purpurea* with *Ochroleuca* or *lutea* and *lutea* with *purpurea* or *ochroleuca* with *purpurea*. From the union of two races of different longevity comes usually a hybrid into which the longer life of one or the other of its parent races is carried whether it comes from the male or female parent species."

Many more instances are given by Gärtner from his own observations and those of others to enable him to reach the following conclusion:

"These examples support the statement of Kölreuter's that the longer life of hybrid plants is to be counted among their usual properties."

With regard to the resistance of hybrids to unfavorable weather conditions he goes on to say:

"With their longevity stands, in the closest relation, the fairly common property of hybrids to withstand lower temperatures than their parental races without injury to their growth and vegetative life. Kölreuter first observed that *Lycium barbara-afrum* in south Germany withstood the winter in the open field; although *Lycium afrum* must be wintered over, at least, in a cold frame. The cross of *Nicotiana Tabaco-undulata*, according to Sageret in France had an increased life, although in a protected place, in open field. W. Herbert reports that *Rhododendron altaclarae*, which is a hybrid union of *R. pontica-cantawbiense* ♀ with the very sensitive *Nepalense arboreum coccineum* ♂, has been grown in the open in England; also Robert Sweet confirms the same result by a hybrid *crinum* and many other hybrids of bulbous plants grown in open field whose parental species must be grown in the hothouse.

"*Lobelia syphilitica-cardinalis* wintered over with a light covering in the winter of 1832-1833 with 5°F in open field. *Lychnicucubalus albus* and *ruber* lasted three years in open field although *cucubalus viscosus* in south Germany did not survive in open field. All hybrids of genus *coccineum* stood over the winter of 1842-1843 with 5°F. in the open, although the pure species seldom lives through our usual winters of 43° to 9.5° F. Prof. Wiegmann reports similar results.

"Very frost sensitive species of Nicotiana and their hybrids did not withstand, under the same conditions, such low temperatures as the afore-mentioned plants; but we have flowered and carried over part of them wherever they were well covered with snow, for example, *N. quadri-valvis glutinosa*, *rustica-quadrivalvis*, these withstood 25° F. and yet have continued blooming although *N. glutinosa*, *quadrivalvis*, *paniculata*, *Tabacum* and *rustica* were already frozen by 32° F. Moreover other crosses of very sensitive and tender species of this genus as *paniculata-Langsdorfii*, *vincaeflora-Langsdorfii*, *vincae-flora-quadrivalvis* have been carried over in an active growing condition two to three years, and *glauca-Langsdorfii* three years in a cold house with 39° to 42°. The hybrid *N. paniculatarustica-paniculata* was kept over in a cold house in the cold winter of 1839-40 but its leaves were yellow. Among all the species of this genus the cross of *N. suaveolenti-macrophylla* showed itself to be the most hardy. On the 16th of October of its first year (1828) its top was frozen but it did not suffer from this, and 12 days later put out a new shoot from the root and its leaves lasted through the winter in a cold house in a fresh, green condition although the other species were yellow and this plant was the first to start into growth in the spring. The same endurance Sageret observed in *Nicotiana suaveolenti-virginica*. All these plants in the last year of their vegetative life seemed to die off more as the result of the unfavorableness of the weather than of old age."

Exceptions are noted by Gärtner in that some species which were not resistant to cold did not give resistant hybrids. In many cases the hybrids were weak because of the distant relationship of the parental races.

Sargent ('94) reports a remarkably vigorous and hardy hybrid tree supposed to be a cross of the tender English walnut, *Juglans regia* and the common butternut *Juglans cinerea*. He says: p. 434

"My attention was first called to the fact by observing that a tree which I had supposed was the so-called English walnut—*Juglans regia*, in the grounds connected with the Episcopal School of Harvard College at Cambridge, was not injured by the cold of the severest winters, although *Juglans regia* generally suffers from cold here— and rarely grows to a large size. This individual is really a noble tree; the trunk forks ab u five feet above the surface of the ground into limbs and girths, at the point where its diameter is smallest, fifteen feet and two inches. The divisions of the trunk spread slightly and form a wide, round-topped head of pendulous branches and unusual symmetry and beauty, and probably sixty to seventy feet high."

Heterosis is also shown in a resistance to bacterial and fungus diseases. Some of the inbred strains of maize are very susceptible

to the bacterial leaf-wilt and in some years at the end of the season all the plants of these strains appear as if they had been scorched by fire while other strains in adjoining rows are untouched. Other strains have quite a large percentage of plants attacked by smut. Crosses, however, of these susceptible strains with those which are not affected by these parasitic organisms are only slightly or not at all affected.

TABLE 28. SUSCEPTIBILITY TO SMUT (*Ustilago zeae*) OF A NON-INBRED VARIETY OF MAIZE, SEVERAL INBRED STRAINS DERIVED FROM THIS VARIETY AND THE FIRST AND SECOND GENERATION CROSSES BETWEEN THE MOST SUSCEPTIBLE AND THE LEAST SUSCEPTIBLE STRAINS.

Pedigree number	Percent of plants affected			Total number of plants grown	Total percent of plants affected
	Plot I	Plot II	Plot III		
1	....	....	1.75	114	1.75
1-9-1-2-4-6-7-5	0	.27	.56	596	.34
1-7-1-2-2-9-2-1	2.17	.35	0	408	.49
1-7-1-1-1-4-7-5	8.79	10.16	5.77	950	9.79
1-6-1-3-4-4-4-2	0	0	0	992	0
(1-6-1-3) × (1-7-1-1) F_1	....	2.48	0	439	2.28
(1-6-1-3) × (1-7-1-1) F_2	....	....	5.15	97	5.15

In Table 28 are given the per cent. of plants affected by smut (*Ustilago zea*, Beck. Ung.) of the original, non-inbred Leaming variety of maize previously spoken of and four inbred strains derived from this variety by ten or eleven generations of self-pollination. Seed of the four inbred strains was planted in three rather widely separated plots in the same field in 1917. Two of the strains showed only a small infection by this parasite; one showed about 10 per cent infection and one had not a single plant affected in all three plots in a total of nearly one thousand plants. Since the differences which these four strains show are fairly consistent in the different places grown it can hardly be doubted but that segregation of susceptibility to parasitism has occurred in the inbreeding process. The first generation hybrid between the most resistant and the most susceptible strain was free from smut in one plot and but slightly affected in another. The second generation hybrid grown side by side with first generation showed

considerably more infection although the number of plants grown was small. This is fairly good evidence that resistance to smut in maize tends to dominate in crosses between plants which differ in this respect.

Tisdale, according to L. R. Jones ('18) also finds that in flax disease resistance tends to be dominant although the hybrids are more or less intermediate in this respect and the method of inheritance is rather complex. Biffen ('12), on the other hand, concluded that the resistance to rust in wheat was recessive. Likewise, Weston ('18) states that maize and teosinte-maize hybrids are extremely susceptible to a downy mildew (*Peronospora Maydis*, Rac.) in Java and other places, although teosinte (*Euchlaena mexicana*, Schrad.) is immune.

Data from another source have been obtained from the garden radish (*Raphanus sativus*, L.). A white-rooted variety of radish was allowed to go to seed alongside a red-rooted radish. Seed collected from the white-rooted plants was sown thickly in a flat and when they came up it was seen that a number of the seedlings were crossed from their red colored stems. The seedlings were quite badly attacked by the "damping-off" fungus and large numbers of them were killed, but a far less number of the crossed seedlings were affected as shown by the decay of the tissues at the base of the stem. The figures obtained are given in Table 29.

TABLE 29. COMPARATIVE SUSCEPTIBILITY TO "DAMPING-OFF" DISEASE OF SELFED AND CROSSED RADISH SEEDLINGS.

Variety of Radish	White Seedlings, Selfed			Red Seedlings, Crossed		
	Number grown	Number affected	Percent affected	Number grown	Number affected	Percent affected
Short, white...	349	142	40.7	30	4	13.3
Long, white...	76	28	36.8	7	0	0

Gernert ('17) reports a case of immunity to aphis attack of teosinte-maize hybrids in which the maize parent was badly infested whereas the teosinte parent and the hybrid entirely escaped injury.

Together with these manifestations of heterosis in its influence on hardiness there is an increase in the viability of crossed seeds as compared to selfed seeds from the same ears as shown in Table

TABLE 30. THE EFFECT OF HETEROZYGOSIS UPON GERMINATION—A COMPARISON OF CROSSED AND SELFED SEEDS FROM THE SAME EARS OF MAIZE

Pedigree number of female parent	Pedigree number of male parent	Percent increase in weight of crossed seeds over selfed	Number of seeds planted of each	Number of selfed seeds germinated	Number of crossed seeds germinated	Percent selfed seeds germinated.	Percent crossed seeds germinated.	Excess of percent crossed seeds germinated over selfed
21-3-13-9-7-57-13	14-10-30-6-2-13-5-13	8.2	121	24	46	19.8	38.0	18.2
21-3-13-9-7-57-17	14-10-30-6-11-3-11-17	18.8	39	26	37	66.7	94.9	28.2
21-3-13-9-7-57-21	14-10-30-6-11-3-11-4	7.1	32	28	29	87.5	90.6	3.1
21-3-13-9-7-57-38	14-10-30-4-4-2-7-38	68.0	22	14	22	63.6	100.0	36.4
21-3-13-9-7-57-39	14-10-30-4-4-2-7-7	18.3	33	16	26	48.5	78.8	30.3
21-3-13-9-7-57-54	14-10-30-4-4-2-7-7	3.9	97	19	27	19.6	27.8	8.2
21-3-13-9-7-57-58	14-10-4-6-4-7-8-15	8.8	100	43	68	43.0	68.0	25.0
21-3-13-9-7-57-59	14-10-4-6-4-7-8-10	10 0	12	9	12	75.0	100.0	25.0
21-3-13-9-7-57-63	14-10-4-6-4-7-8-29	17.5	31	26	30	83.9	96.8	12.9
21-3-13-9-7-57-64	14-10-4-6-4-7-8-29	13.3	14	9	14	64.3	100.0	35.7
21-3-13-9-7-57-65	*	13.5	47	41	45	87.2	95.7	8.5
14-10-30-4-4-2-7-12	21-3-13-9-7-57-38	8.3	87	84	86	96.6	98.9	2.3
	Total	16.3	635	339	442	53.4	69.6	16.2

* Seeds crossed but number of parent unknown.

30. Seeds which were secured from some of the mixed pollinations, reported previously, were sown in flats. Without exception the crossed seeds showed a higher percentage of germination than the selfed seeds from the same ears as can be seen in Plate XIb. These seeds were planted two months after ripening. Whether or not an increase in age would show greater differences in viability is not known but it is quite likely that the difference might become even greater with age up to a certain point. The low germination of both crossed and selfed seeds in some of the ears was due to the fact that they were moldy on account of late ripening and damp weather.

The increased vegetative vigor as manifested by an increased facility of vegetative propagation in hybrids has been repeatedly spoken of. Kölreuter, Wiegmann, Sageret and Focke make a special mention of this phenomenon.

Moreover there is no positive evidence that plants which are propagated vegetatively lose any of their hybrid vigor which

they may have, no matter how many generations of asexual reproductions take place. Undoubtedly most varieties of cultivated fruits, flowers, ornamental plants and field crops which are commonly propagated vegetatively, owe their excellence in part to heterosis.

From time to time the supposed degeneration of plants in long-continued vegetative propagation has been much disputed. Knight ('99) and Van Mons ('36) contended that they did degenerate, but Lindley ('52) reviewing Knight's work thought that the evidence did not support such a view. Gärtner states that the characteristics of a hybrid do not change throughout the whole life cycle of the individual, even when it is propagated and disseminated by buds, cuttings or layers.

Darwin believed that a degeneration took place largely for the same reason that he thought long continued self-fertilization was injurious. Asa Gray ('76), in reviewing Darwin's opinions on this matter, says (p. 347):

"The conclusion of the matter, from the scientific point of view is, that sexually propagated varieties of races, although liable to disappear through change, need not be expected to wear out and there is no proof that they do, but that non-sexually propagated varieties, though not especially liable to change, may theoretically be expected to wear out, but to be a very long time about it."

Gray, however, cites cases of horticultural varieties propagated since the time of the Romans with no apparent loss of vigor. Whitney ('12a, b, c) and A. F. Shull ('12b) believe that an actual degeneration takes place in parthenogenetic reproduction in the rotifiers. The work of Enriques ('07), Woodruff ('11) and Jennings ('12) on Paramecium proves almost beyond doubt that there is no degeneration in this organism although reproduction by fision in the infusoria may be considerably different from vegetative propagation in the higher plants. Hedrick ('13), from the evidences of long-continued varieties of fruits, and East ('08) working with potatoes and reviewing extensively the whole question believe that there is no evidence that a real degeneration takes place which cannot be accounted for on the basis of the accumulation of disease or other external effects. East ('10), however, suggested that such a degeneration, if ever proven, might be accounted for on the basis of a decreasing effect of the physiological stimulation assumed to be derived from heterozygosity. A. F. Shull (12a)

holds a similar opinion. From the nature of the problem it can hardly be settled satisfactorily one way or the other by experimental means. As it stands at present there is no clear evidence that there is a degeneration in long continued asexually propagated plants. The burden of proof rests with the positive side.

THE EFFECT OF HETEROZYGOSIS UPON THE TIME OF FLOWERING AND MATURING.

Many investigations have indicated that there is a hastening of the time of maturity due to heterozygosis. That there is an acceleration in the rate of growth is, of course, evident from the great increase in size shown by hybrids grown in the same season with their parents. There is, moreover, considerable evidence from previous work and from the data to be given here to show that hybrids not only grow to a larger size but complete their growth in a shorter time than the parents take to complete a smaller amount of growth. In other words, heterozygosis tends to hasten the time of maturity as well as to increase size.

The investigations of Kölreuter, Gärtner, Focke and Darwin show a large number of specie- and variety-crosses wherein the hybrid flowers before either of the parents. Both Kölreuter and Gärtner give instances of perennials which commonly bloom in the second or third year whose hybrids bloom in the first year.

The most extensive observations bearing on this relation of heterosis to time of flowering are those given by Darwin in his "Cross and Self Fertilization in the Vegetable Kingdom." He gives the time of flowering of 28 crosses between different strains within many different species—which show positive evidence of hybrid vigor. Of these 28 crosses 81 per cent. flower before the parents. Four cases are given where the crosses are less vigorous than the parents and in each of these the parents flowered first.

Recent experiments in hybridization show, almost without exception, that crosses which result in an increase in vigor also result in a hastening of the time of flowering. One exception to this statement must be noted in the cross between a large dent and a small pop variety of corn reported by Emerson and East ('13). This cross showed distinct evidence of hybrid vigor in an increase in internode length over that of both parents. The parents differed in time of flowering by 25 days. The first generation of the cross grown the same year as the parents was "distinctly

intermediate" in time of flowering. There was an increase in the rate of growth necessarily as the plants were larger than the average of the parents.

Data bearing upon the relation of heterozygosis to the time of maturing has been secured from two different plants, tomatoes and corn. A large part of the data on tomatoes was collected by Prof. H. K. Hayes, now at the Minnesota College and Station.

Four commercial varieties of tomatoes were successively self-pollinated for four years. Two first generation crosses between these varieties were grown in each of the four years and compared as to yield of fruit and time of production with the two selfed parents. In every case the same plants which were used to produce the selfed seed for the next generation were also used to make the crosses. For this reason and because tomatoes are naturally self-pollinated and are hence in a homozygous condition the first generation crosses can be compared strictly with their parents.

From thirty to fifty plants of each variety and cross were grown each year. The fruit was picked as it ripened at intervals of from 3 to 5 days and the average production per plant was determined. One of the crosses was between varieties which had approximately the same time of ripening. This first generation cross did not exceed, in total yield, the average of the two parents and did not differ from them in respect to time of production.

The other cross, however, yielded, each year, an average of 16 percent above the better parent. The two varieties used in making this cross differed in time of production by an average of five days. The first generation cross while yielding 16 percent more than the late parent was each year fully as early as the early parent. Although the difference in time of production between these varieties is small the consistent results obtained in four successive years are certainly significant.

Similar results were secured with sweet corn. A first generation cross between an early variety of sweet corn, Golden Bantam and a late variety, Evergreen, was grown in 1916 together with the two parental varieties and compared in time of flowering, number of ears per plant and in height. They were all planted at the same time but rather late in the season so that the early and late varieties bloomed at more nearly the same time than is usually the case. About half of the plants of the early variety were

showing silks before the late variety commenced to silk out The first generation cross was slightly earlier than the early parent in producing silks. The cross was noticeably affected by vigor of crossing in that it was fully as tall as the taller parent and averaged more ears per plant than either parent although the ears were not as large as those of the Evergreen variety.

Much more extensive and authoritative data have been secured from a comparison of inbred strains of corn with their first generation crosses. Forty-two strains of corn which had been continuously selfed for from 5 to 11 generations and 100 first generation crosses representing different combinations between these selfed strains were grown under the same conditions as to time of planting and culture. Both the inbred strains and their crosses were exceedingly uniform in time of flowering and maturing. All the plants in any selection flowered and matured within a few days. About 60 plants of each were grown. At intervals of one week during the flowering season the number of selections of the selfs and crosses which had flowered by that time were noted. Similarly at the end of the season the selections which were mature were noted at intervals. Although the time of maturity can not be so definitely determined as the time of flowering all the plants in a selection were uniform in this respect. For the flint varieties the glazing of the ears and for the dent varieties the denting of the kernels were taken as indications of maturity. The crosses yielded, on the average, 180 per cent more than their parents.

Together with this increase in the amount of growth there was a noticeable hastening of both the time of flowering and maturing. In time of flowering the crosses were four days and in maturing eight days earlier than the average of their parents. Since the crosses gave a large increase in the total amount of growth and produced this growth in a somewhat shorter time than their inbred parents it is all the more evident that heterozygosis increases the rapidity of growth. See Plates VII a and b.

The Relation of the Effects of Heterozygosis and of the Environment.

East ('16) has stated that heterozygosis "affects a result comparable to favorable external conditions." In a cross between two varieties of *Nicotiana* he found that the first generation

gave a noticeable increase in the amount of growth as shown by the height and general size of the plant as the result of heterozygosis. The corolla length of the flowers, which is very little affected by environmental factors, was not increased above the average of the two parents.

The similarity of the effects of heterozygosis to the environmental effects is also shown in the affect of crossing on the number of nodes and internode lengths of corn. As was noted from Tables 15 and 13 the number of nodes is increased only 6 percent while the height of plant is increased 27 percent. This is exactly the effect that nutritional factors have. The height of plant is reduced under poor conditions by a reduction in internode length without reducing appreciably the number of nodes.

In general it is evidently true that heterozygosis affects many characters in the same way as the environment, but it should be noted that in time of maturity these two factors have directly opposite effects. It is generally recognized, I believe, that favorable external conditions such as increased moisture or fertility, where these are limiting factors, which result in a greater total amount of growth tend to prolong both the time of flowering and the completion of growth. Conversely unfavorable external conditions which stunt the plants and limit their growth tend to hasten their period of flowering and maturity. There are, of course, certain exceptions to this statement.

Whether or not the effect of heterozygosis in hastening maturity can manifest itself independent of any increase in vegetative luxuriance or other manifestations of hybrid vigor is not known. The results given here would indicate that the vigor derived from crossing enables the plant to carry on its life processes more easily and more efficiently and thus to accomplish its task in a shorter time.

With regard to the effects of heterozygosis in animals much the same relation is shown with the external environmental effects as in plants although the rate of growth and size obtained at maturity may be more definitely fixed in animals than in plants. According to Castle ('16) there is an increase in the rate of growth as well as the attainment of a larger size at maturity in hybrid guinea-pigs. Hyde ('14) also finds an increase in rate of growth and hastening of sexual maturity on crossing in Drosophila. These effects in animals are probably greater than could

be obtained by any amount of feeding or care just as it is the case in plants.

It may be stated briefly that the effects of heterozygosis in both animals and plants, not too distantly related, all together contribute towards an increased reproductive ability and this effect has probably been of fundamental importance in evolution in establishing sex.

In the foregoing account of some of the most noticeable effects of crossbreeding upon development we have been dealing only with crosses among closely related organisms. It is of course, well known that in crosses between distantly related forms the beneficial effects of crossing may disappear and the effects become increasingly more injurious as the degree of dissimilarity becomes greater. The most frequent, pronouncedly injurious effect is the reduction or complete loss of fertility. This may or may not be accompanied by a great acceleration of growth. This is shown in many plants, notably by Gravatt's Radish-Cabbage hybrid and by Wichura's Willow hybrids as well as by many good illustrations given by Gärtner and Focke. It is perhaps not surprising that the reproductive ability should be the first to suffer since reproduction is the most difficult task the organism has to perform. The failure of the reproductive mechanism might divert the energies into bodily growth and thus in part account for the large size and great vigor of some sterile hybrids but, as all are agreed, this can not entirely account for the great increases in size nor obviously does it apply to the more common cases where both size and productiveness are increased at the same time.

To sum up one can therefore say that, in plants, crossing may have a great range of effects, according to the degree of relationship of the parents, from a condition in which: the cross is not possible and no seed produced; seed may be produced but fail to germinate; plants may be produced which are either very weak, normal or very vigorous without being able to reproduce themselves; plants which are both more vigorous and more productive than their parents; to a condition in which they are so closely related that the crossed plants do not differ appreciably from selfed plants. A similar series can be arranged with animals.

Summary of the Effects of Inbreeding and Crossbreeding.

Before taking up a theoretical consideration of the cause of hybrid vigor and its importance in the establishment of sex it is well to summarize briefly some of the main conclusions, with regard to the effects of inbreeding and crossbreeding on development, to be arrived at from a study of the investigations discussed.

EFFECTS OF INBREEDING.

1. Continued inbreeding results in the segregation of a variable complex into a number of diverse types which are uniform within themselves.

2. The segregates which differ in visible, qualitative characters also differ in quantitative characters; types with abnormalities appear which cannot reproduce themselves; others appear which are perpetuated with difficulty; others are obtained which are perfectly normal in structure and function. These latter are usually less well developed, but may be as well or better developed than the original stock from which they are derived.

3. The change in size, structure, or function and reduction in variability is most noticeable in the earlier generations of inbreeding, rapidly becomes less and the surviving inbred strains are uniform and constant.

4. The rate of approach to uniformity and constancy differs in different lines.

5. These uniform and constant inbred strains are quite comparable to naturally self-fertilized species.

6. No single effect can be attributed to inbreeding other than the reduction in variability.

7. All these results are in conformity with Mendel's law and Johannsen's genotype conception.

THE EFFECTS OF CROSSBREEDING.

1. Heterosis accompanies heterogeneity in germinal constitution whether or not the organisms crossed are from the same or diverse stocks.

2. Heterosis is widespread in its occurrence throughout the plant and animal kingdoms.

3. Heterosis is shown as an increase in the size of parts rather than an increase in the number of parts.

4. Cross-fertilization is without effect until the zygote is formed; from that time on heterosis may be apparent throughout the life of the individual.

5. Heterozygosis has an undiminished effect on plants propagated vegetatively.

6. Heterozygosis may have a stimulating effect on some characters and a depressing effect on others in the same organism.

A Mendelian Interpretation of Heterosis.

It is due to the work of G. H. Shull ('08, '09, '10, '11) and of East ('08, '09) and East and Hayes ('12), supplemented and confirmed by the results given here, that we no longer believe that inbreeding is a process of continuous degeneration. Also these investigators first demonstrated clearly that the same principle was involved in the loss of vigor accompanying inbreeding and the increase in vigor resulting from crossing.

To account for this well nigh universal loss of vigor when domesticated races of plants and animals are inbred, they thought it necessary to assume a physiological stimulation which was present when unlike germplasms were united and which disappeared as homozygosis was brought about automatically by inbreeding. Part of the effects of inbreeding were due, according to their views, to the segregations into pure lines of different hereditary complexes and the appearance of previously hidden recessive characters, and part were due to the loss of this stimulation.

G. H. Shull's ('14) opinion as to the way germinal heterogeneity induces vigor is stated briefly as follows (p. 126):

"The essential features of the hypothesis may be stated in more general terms as follows: The physiological vigor of an organism, as manifested in its rapidity of growth, its height and general robustness, is positively correlated with the degree of dissimilarity in the gametes by whose union the organism has been formed. In other words, the resultant heterogeneity and lack of balance produced by such differences in the reacting and interacting elements of the germ-cells act as a stimulus to increased cell-division, growth, etc. The more numerous the differences between the uniting gametes—at least within certain limits—the greater, on the

whole, is the amount of stimulation. These differences need not be Mendelian in their inheritance, although in most organisms they probably are Mendelian to a prevailing extent."

Both the view stated above and that of East and Hayes assume that the increase in development is due to a reaction between different elements in the nucleus and that this stimulus disappears when homozygosity is reached. A. F. Shull ('12a) has proposed a slightly different idea in that he assumes the stimulus to be due to the reaction of new elements in the nucleus, brought in by cross-fertilization, to the maternal cytoplasm. According to his view there might still be a stimulation even after complete homozygosity is attained. Also in asexual propagation he supposes that the cytoplasm might become gradually accustomed to a heterozygous nucleus, hence long continued asexual reproduction might lead to a gradual reduction in vigor which this writer finds does occur in the rotifer, *Hydatina senta*. ('12b).

It should be remembered, however, that both these hypotheses, as to the effect of germinal differences, postulate a stimulation to account for an increase in development as the facts demand. It would have been even more plausible to postulate a depressing effect had the facts been otherwise. The only basis for a stimulation of this kind is in the fact that fertilization initiates the development of the egg. Heterozygosis, however, is not concerned with the starting of the development of the egg, but only with the rate of development after growth is commenced. Is it not more plausible that "a lack of balance" occasioned by the union of unlike germplasms would retard development rather than stimulate it?

Keeble and Pellew ('10) first suggested that dominance of characters contributed by both parents might be a factor in the increased vigor of hybrids. They illustrated this conception by a cross between two varieties of peas which possessed features of both parents, and were taller than either.

Bruce ('10) has shown that the total number of dominant factors is greater in a hybrid population than in either parental population and that there is consequently a correlation between the number of dominant factors and hybrid vigor. As far as I know, Bruce has never followed up this suggestion. He did not show why it was that the presence of a greater number of dominant factors brought about an increase in growth, nor did he

show why it was that all the dominant features could rarely or never be accumulated in certain individuals and races which would therefore show no reduction in vigor when inbred.

East and Hayes ('12) attempting to distinguish between dominance and the effects of heterozygosis make the following statement (p. 31):

"The term vigor has hitherto been used with the general meaning which the biologist readily understands. We will now endeavor to show in what plant characters this vigor finds expression. It is not an easy task because of the possibility of confusing the phenomenon of Mendelian dominance with the physiological effect due to heterozygosis. The confusion is due to a superficial resemblance only. Dominance is the expressed potency of a character in a cross and affects the character as a whole. A morphological character, like the pods of individual maize seeds, or the product of some physiological reaction like the red color of the seed pericarp in maize, may be perfectly dominant, that is, it may be developed completely when obtained from only one parent. Size characters, on the other hand, usually lack dominance or at least show incomplete dominance. The vigor of the first hybrid generation theoretically has nothing to do with these facts. This is easily demonstrated if one remembers that the increased vigor manifested as height in the F_1 generation cannot be obtained as a pure homozygous Mendelian segregate, which would be possible if due to dominance. Furthermore, the universality with which vigor of heterozygosis is expressed as height shows the distinction between the two phenomena. If the greater height were the expression of the meeting of two factors (T_2, t_2, x t_1, T_2) both of which were necessary to produce the character, one could not account for the frequency of the occurrence. Nevertheless, in practice the confusion exists, and while we have considerable confidence in the conclusions drawn from our experiments, we have no intention of expressing them dogmatically."

G. H. Shull's statements of the way in which crossing brings about increased development, and the relation that this stimulation of growth has to dominance of Mendelian characters is fairly stated, I believe, in the following passage ('11, pp. 244–245):

"In 1908 I suggested a hypothesis to explain the apparent deterioration attendant upon self-fertilization, by pointing out that in plants, such as maize, which show superiority as a result of cross-fertilization, this superiority is of the same nature as that so generally met with in F_1 hybrids. I assumed that the vigor in such cases is due to the presence of heterozygous elements in the hybrids, and that the degree of vigor is correlated with the number of characters in respect to which the hybrids are heterozygous. I do not believe that this correlation is perfect, of course, but approximate, as it is readily conceivable that even though the general principle should be correct, heterozygosis in some elements

may be without effect upon vigor, or even depressing. The presence of unpaired genes, or the presence of unlike or unequal paired genes, was assumed to produce the greater functional activity upon which larger size and greater efficiency depend. This idea has been elaborated by Dr. East and shown to agree with his own extensive experiments in self-fertilizing and crossing maize. He suggests that this stimulation due to hybridity may be analogous to that of ionization.

Mr. A. B. Bruce proposes a slightly different hypothesis in which the degree of vigor is assumed to depend upon the number of dominant elements present, rather than the number of heterozygous elements. While all of my data thus far are in perfect accord with my own hypothesis, and I know of no instance in which self-fertilization of a corn-plant of maximum vigor has not resulted in a less vigorous progeny, it is quite possible that I have still insufficient data from which to distinguish between the results expected under these two hypotheses. However, for the purpose of the present discussion, it is not necessary to decide which of these two hypotheses (if either) is correct. Both of them are based upon the view that the germ-cells produced by any plant whose vigor has been increased by crossing are not uniform, some possessing positive elements or genes not possessed by others."

A. F. Shull does not consider dominance as an adequate means of accounting for heterosis, agreeing with East and Hayes and G. H. Shull, as the following quotation shows: ('12a, p. 10)

"The view that vigor depends upon heterozygosis of the individual seems to me inherently more probable than that it is due to the presence of certain dominant genes. The former view admits of a plausible foundation in cell physiology, and the essence of it may be extended to cases of decrease of vigor in which there is no change in genotypic constitution, and which are therefore without the pale of either theory."

Castle is also in accord with the general belief that heterosis is not due to dominance of factors and draws a distinction between the effects of inherited characters and the stimulus resulting from crossing. In speaking of the increase in size in crosses between diverse races of guinea-pigs he says: ('16, p. 212.)

"So far as heredity is concerned, the inheritance is blending, but F_1 shows an increase in size due to hybridization. This increased size, however, does not persist into F_2. It seems to be due not to heredity at all."

(And again on pages 223 and 224.)

"Cross breeding has, then, the same advantage over close breeding that fertilization has over parthenogenesis. It brings together differentiating gametes, which, reacting on each other, produce greater metabolic activity. Whether or not the uniting gametes differ by Mendelian unit-characters

is probably of no consequence. That they *differ chemically* is doubtless the essential thing in producing added vigor. Heterozygosis is mentioned merely as an evidence of such chemical difference."

These quotations suffice to show that a distinction is held by biologists at the present time between the effects of inbreeding and cross breeding and of heredity in development, and they believe that dominance of hereditary factors is inadequate to account for the widespread, if not universal phenomenon of heterosis. The reason why biologists in general have refused to believe that dominance was in any way responsible for the increased vigor of hybrids has been due to two objections which have seemed to make this hypothesis untenable. They thought that if hybrid vigor was due to the dominance of definitely inherited characters that all these favorable characters which bring about heterosis could be easily recombined into a homozygous individual which would show no reduction on subsequent inbreeding. Since no clear case was known in maize where a plant did not lose vigor on inbreeding this seemed to be a convincing argument. Another objection to dominance as a means of accounting for heterosis was raised by Emerson and East ('13) in that the distribution in F_2 should be unsymmetrical in respect to those characters in which heterosis was shown in F_1. Since the usual frequency distributions in cases of this kind are symmetrical, this objection appeared to be valid.

How both of these objections do not hold when linkage of heredity factors is taken into consideration, the writer has attempted to show in a recent publication ('17). Because of linkage, characters tend to pass from one generation to the next in groups and are not easily recombined. Furthermore, on account of linkage skewness is not expected in the second hybrid generation. All of the recently acquired knowledge of heredity makes it seem highly probable that heterosis may be largely, if not entirely, accountable on the basis of dominance of linked factors.

In considering these two hypotheses, both attempting to account for heterosis, the following facts about dominance should be kept in mind:

1. Partial dominance of characters is a widespread occurrence in plants and animals.

2. Dominance, of course, does not appear until after the zygote is formed.

3. In most cases dominance does not change throughout the life of the individual and remains the same through innumerable clonal generations.

While none of these features of dominance offers any definite means of proving the truth of the hypothesis advanced, is it only a coincidence that they fit in exactly with what the facts of heterosis demand? It remains to show that those characters which enable a plant or animal to obtain the best development are, for the most part at least, partially dominant over those characters which retard or prevent maximum growth.

The essential difference between the two hypotheses may be stated briefly. According to the previous view the hybrid combination of factors Aa carried the ability to stimulate development because of the union of unlike elements. This stimulation was absent in either of the homozygous combinations AA and aa, and this stimulation had no direct relation to the part that either A or a had in development as hereditary entities. According to the conception of dominance, first proposed by Keeble and Pellew and carried out more fully by the writer, the hybrid union of AAbb with aaBB, resulting in the heterozygous combination of Aa Bb, increases development because two dominant characters are present here together, whereas each parent has only one dominant character. A similar factorial arrangement has been proposed by Hyde ('14) to account for the increased fertility of his crosses among partially sterile strains of Drosophila.

In crosses between different types of domesticated animals and of cultivated plants it has frequently been noted that there is a tendency towards a return to the characters of the wild species from which they were derived. Sageret ('26) makes particular note of this point. It is well known that crosses between different breeds of pigeons is quite apt to bring back the wild-type of plumage. The hybrid between radish and cabbage described by Gravatt ('14) illustrates this point strikingly. The hybrid produced had neither a succulent "head" like its cultivated male parent nor a fleshy root like its female parent. In other respects, as well, it showed this return to wild-type characters. It was also exceedingly vigorous, but sterile, like so many hybrids between diverse stocks.

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Drosophila furnishes the best illustration of the appearance of wild type characters in the first hybrid generation. Of the more

than one hundred mutations found in Drosophila by far the largest number of these are recessive. Almost all of them are characters which are less favorable to development. It is stated that any attempt to collect a large number of the recessive characters into one race is rendered difficult by the weakened constitution of the flies possessing any great accumulation of recessive characters (Muller, '16). Whenever crosses are made between diverse types the first generation fly is in many of its characters more like the wild stock and hence more vigorous than its parents. All lethal factors, well illustrated in Drosophila, furnish additional support to the hypothesis of dominance as a means of accounting for heterosis. Muller ('17) has shown that a condition of "balanced lethals" may be brought about in which only the heterozygotes can live. As dominant lethal factors are always eliminated as soon as they occur, so, also, is there always a strong tendency for selection to eliminate any dominant character which is at all unfavorable to the organism's best development. Unfavorable recessive factors also tend to be eliminated, but much more slowly.

If the results obtained in Drosophila are applicable to other animals and to plants we must infer that recessive mutations occur the most commonly. Hence recessive mutations make up the characters, to a large degree, that man has selected in the production of domesticated animals and plants. Just as in Drosophila, crosses between diverse domesticated types tend to result in the reappearance of wild-type characters which are more useful to the plant or animal whose chief aim in life is, apparently, to reproduce itself.

This is well shown in an illustration from maize. As stated before, inbred strains have been obtained which are markedly deficient in root development. On these plants the large brace roots which commonly appear when the plants begin to need extra support, are almost completely lacking. Consequently, the plants are blown over when they become heavy at the time of ear formation. I have observed these strains three years and each time they have fallen down. This character is not determined by soil conditions or insect damage or any external conditions as far as can be seen. Other plants on either side are perfectly upright. When these strains are crossed with other strains, inbred for an equal or longer period, which have well developed brace roots, the first hybrid generation has remarkably well developed brace

roots, and usually does not show the slightest tendency to go down, as shown in Plates XIIa and b. Emerson ('12) describes similar plants in which the root deficiency is also recessive. Another striking feature is shown in this illustration. The inbred strain which lacks brace roots is derived from a floury variety of corn and shows a decided tendency to branch at the base of the stalk. These branches form stalks with tassels and ears and many of them are fully as well developed as the main stalk. In this way two or three stalks may be developed from one seed. The other parent of the cross shown never branches in this way and never even develops small branches or "suckers." The first hybrid generation shows this tendency to branch even more strongly developed than the branching parent. The plants shown are from three hills grown side by side and each hill is the product of three seeds. Thus it will be seen that both parents have contributed characters to the hybrid. Both these characters are such as to enable the plants to attain a greater development in general vegetative luxuriance than would be possible if either were lacking. Emerson ('12) gives an even better illustration of two extremely unproductive types of maize which give a vigorous hybrid, one of the parents contributing tall stature, the other green chlorophyll.

Many more illustrations of a similar operation of hereditary factors favoring a hybrid in its development might be cited. I believe that enough have been given to clear the way towards the acceptance of the doctrine that hybrid vigor is due largely to the normal functioning of definable, hereditary factors.

It is recognized that the characters used as illustrations here are superficial in nature. The characters which are really concerned in heterosis are those deep-seated, fundamental, physiological processes which govern metabolism and cell-division. As to the mode of inheritance of these characters we, as yet, know little. There is no reason to believe, however, but that many or all of them are Mendelian in mode of inheritance and that many of them operate in the same way to enable hybrid progeny to attain a more complete development than their parents. If this hypothesis, as to the way in which heterosis is brought about, is in its essential features correct, it points the way towards a more fundamental application of Mendelism to the physiological processes of growth than is generally acceded.

There now remains to be discussed the part that crossing-over or breaks in the linkage of hereditary factors would play according to this hypothesis. If any large number of characters are concerned and the dominant and recessive genes are equally apportioned between the two parents, and distributed at random on the chromosomes, the chance of crossovers occurring in such a way as to bring all the dominant factors in one individual at one time would be almost inconceivably small, especially when the phenomenon of interference is taken into consideration. However, when crossing-over does occur in such a way as to bring about more fortunate combinations in certain individuals, those individuals would be the ones selected by man in domesticated races, or by nature in the wild. Partial linkage does not prevent recombination but merely adds to the complexity of the process. The chance of fortunate recombinations would be greater in the more widely crossed animals and plants but such combinations would be again broken up by further crossing. The tendency would be, however, for the best combination of characters to survive and gradually supplant the others in time. In naturally selfed plants, most of which are crossed at more or less infrequent intervals, a fortunate homozygous combination would be fixed and the plants possessing such combinations would in time supplant their less fortunate relations.

Thus there would always be the tendency for all the more favorable characters to be gathered together and the others eliminated. In time all the individuals of a locality would tend to become equal in their hereditary characters and crossing between individuals in a given locality would not accumulate any greater number of favorable characters than the parents possessed and hence would not show any evidences of heterosis.

That this is the condition which is brought about Darwin has shown. Individuals from the same locality derive little or no benefit from crossing while crosses between individuals from different geographical regions show a greater effect of crossing. The work of Collins ('10) and the results obtained at the Connecticut Station (Jones and Hayes '17) show this also—varieties of maize of similar characters and from the same region give less increase when crossed than do varieties of diverse type or from widely separated geographical regions.

If by crossing-over and subsequent recombination the characters which bring about the great development in F_1 can all be accumulated in a homozygous condition in an individual, that individual should show a greater development even than the F_1 as A. F. Shull ('12) has pointed out. This is on the assumption that most characters which play a part in heterosis are not fully dominant. That a factor in the diploid condition has a greater effect than when in the haploid condition is indicated by the work of Hayes and East ('15) on endosperm characters in maize. Their results show that in reciprocal crosses a double dose of one allelomorph in the maternal endosperm fusion nucleus overcomes a single dose in the paternal endosperm nucleus. In other words factors have an accumulative effect.

The evidence that such superior individuals have been obtained by inbreeding is not very convincing it must be admitted. Darwin, however, in Ipomea obtained plants—"Hero" and its descendants—which were certainly no less vigorous than any plants at the beginning of the inbreeding period and the same thing occurred in Mimulus. These are the two species which were the most extensively inbred. Miss King, as mentioned before, has obtained inbred rats which are larger and more vigorous than individuals present in the original stock. Nothing of this kind has occurred in maize and on account of the small chance of recombining many of the most desirable characters in one plant, it is not at all surprising that such individuals have not as yet been produced.

The production of individuals by inbreeding which excel any of the original crossbred stock offers some means of deciding between the two hypothesis attempting to account for heterosis. According to the hypothesis of a physiological stimulation it would be difficult to see how individuals more vigorous than the parents could be produced by inbreeding.

The hypothesis of dominance also, possibly, makes it easier to understand why naturally crossed wild species, which have not been outcrossed with fresh stocks for long periods of time, may not show any markedly injurious effects from artificial inbreeding. According to the former view different characters of equal value to the organism which might persist indefinitely in a species, would supply a stimulation when united in a heterozygous combination. This stimulation would be lost whenever individuals

were reduced to homozygosity by artificial self-fertilization. According to the view of dominance if the allelomorphs were all equal in their contributions to development there might be differences in a species and still no loss of vigor would result from inbreeding. It is assumed that the less favorable characters have been eliminated by selection. On either hypothesis there would be no reduction from inbreeding if all the members of species were exactly alike whether they are naturally crossed or naturally self-fertilized.

The hypothesis of physiological stimulation also implies the assumption that naturally crossed species of cultivated plants are inherently more efficient as producers than naturally selfed plants. This is hardly justified when we recall such vigorous and productive plants as wheat, oats, barley, rice, peas, beans, tobacco, tomatoes and many others which are usually self pollinated. It is, however, difficult to make a fair comparison on this basis.

To sum up, it may then be stated briefly that dominance of characters as opposed to the former idea of an indefinable physiological stimulation makes more understandable the facts that:

1. Heterozygosis produces a stimulating, and not an indifferent or depressing effect in crosses between related stocks and that the reverse is true in widely diverse stocks.

2. Heterozygosis operates throughout the lifetime of the individual even through many generations of vegetative propagation.

3. Inbreeding may result in individuals more vigorous than the original cross-bred stock.

4. Inbreeding may not bring about a reduction in some naturally crossed wild species.

Whether or not dominance of factors is wholly adequate to account for all of the immediate effects of exogamy remains to be seen. The former view that dominance was not concerned at all has been maintained so insistently that I have taken the extremely opposite view in order to show that dominance at least can be held responsible for a large part of the increased development shown by hybrids. The treatment of the subject in this light has been dogmatic. That cross-fertilization may produce some effect which can never be attained in self-fertilization or a sexual reproduction is still possible. The view of the problem

which is presented here makes certain heretofore indefinite effects more intelligible. It is not meant to preclude entirely any beneficial physiological stimulation resulting from germinal diversity, if such an effect can be demonstrated.

The difference between the two hypotheses are not as great as might seem at first sight. The older hypothesis is general in its application and does not commit itself to the interpretation of specific effects. The view presented here is specific in its application and may be shown to be inadequate for the interpretation of all phases of the problem of increased development following cross-fertilization.

The greatest progress in our knowledge of inbreeding and cross-breeding was made when their effects were linked with Mendelian phenomena. This was the big step forward. The two ways of interpreting these effects discussed here, differ only in minor features and it is not putting the matter fairly to hold them up as two rival hypotheses, one to be chosen from the other. Placing the effects of inbreeding and cross-breeding entirely on a Mendelian basis is merely the logical outgrowth of the older view as knowledge of the methods of inheritance increased.

THE PART THAT HETEROSIS HAS PLAYED IN THE ESTABLISHMENT OF SEX.

Since heterosis is widespread in its manifestation it can hardly be doubted that it has played some part in the initiation and maintenance of sexual differentiation in organisms. Jennings ('13), however, has shown that conjugation in Paramecium does not result, immediately, to the advantage of the organism. The rate of reproduction is actually diminished and many of the organisms perish. The advantage which is derived from conjugation, he considers with Weismann, is due to the fact that biparental inheritance makes possible a greater variability and consequently a greater chance of recombinations, some of which are better able to persist. Hence, while many offspring from conjugating paramecia die, some may be able to survive. Conjugation therefore makes possible a greater elasticity in adaptiveness to new and varied surroundings.

If this immediately depressing effect found in Paramecium is general in the lower animals, heterosis would probably have

played no part in the inauguration of sex. Both A. F. Shull ('12a) and Whitney ('12a) have shown, however, that heterosis occurs in the rotifer, *Hydatina senta.*

In the lower plants heterosis would have significance only in spore formation, as the main life of the plant is carried on in the haploid condition where heterozygosis could not, of course, operate. As organisms became more differentiated and specialized the accumulation of factors in the zygote from two somewhat different parents would have increasing significance. If, for example, an organism should vary in a character A by one new dominant mutation A′, the heterozygote AA′, according to the hypothesis of dominance, would be superior to the combination AA but not to the combination A′A′. According to the former view of a physiological stimulation the heterozygous combination AA′ might be superior to either homozygous combination. The matter is not so simple as this, however. The breeding facts show that recessive unfavorable variations are far more common than dominant favorable ones. The chances would be that those individuals which varied by dominant mutations would also vary from the parental stock, sooner or later, by recessive mutations as well, so that any hybrid union would tend to accumulate more favorable factors than either parental individual possessed and hence show heterosis. Heterosis would be an immedate factor for natural selection to work upon.

Moreover it seems possible that heterosis has had considerable to do with the rise of the sporophyte and the decline of the gametophyte in plants. Recombination of characters can take place as well when the dominant generation is the haploid as well as when it is diploid in respect to the chromosome arrangement. From the standpoint of adaptiveness through recombination of characters it might even be to the organism's advantage to retain the haploid generation as the one in which the principal life processes were carried on, since the different combinations would then be more surely tested and the best more easily selected in the simplex than in the duplex condition. Heterosis can only operate in the sporophyte. The union of different hereditary complexes gives to the sporophyte an advantage over the gametophyte in that all new favorable variations work together whereas segregation in the formation of the gametophyte reduces the efficiency of this generation. On the basis of the

complimentary action of factors according to the dominance hypothesis of heterosis the gametophyte would practically always be at a disadvantage as compared to the sporophyte as long as variations were occurring so that heterosis must have played some part in these important changes.

Either on the basis of inducing variability or stimulating development, sex would be a creation of no value to organisms which are never cross-fertilized. It may be questioned if many such exist. In either case the sexual mechanism is so complex and deep-seated in the life of the organism that it is not to be discarded easily. Whenever the best possible combination of factors for a given environment is produced, it is to the advantage of the organism possessing that combination to give up cross-fertilization and resort to either self-fertilization or some form of sexual reproduction, for the reason that these are more efficient means of propagation. When the environment changes, those organisms which are *not cross-fertilized* may either be doomed to extinction or handicapped in becoming adapted to new conditions and the perpetuation of the sexual mechanism thereby accounted for.

Whatever may be the value or significance of heterosis, to account for this phenomenon it is, for the most part, unnecessary to assume that there is an indefinite stimulating effect of hybridization along with the expression of definable hereditary factors. Hence the distinction is no longer needed between the effects of self-ferti ization and cross-fertilization and of heredity in development. The heretofore indefinite physiological stimulation resulting from heterozygosis and the related effects accompanying the loss of this stimulation following inbreeding can therefore be given a strictly Mendelian interpretation.

This being so there is no longer a question as to whether or not inbreeding *per se* is injurious. Whether good or bad results from inbreeding depends solely on the constitution of the organisms before inbreeding is commenced. Inbreeding is concerned only with the manifestation of conditions pre-existing. As a means of analyzing and of purifying a cross-bred stock by the elimination of undesirable qualities, inbreeding is therefore a method of first importance in plant and animal improvement.

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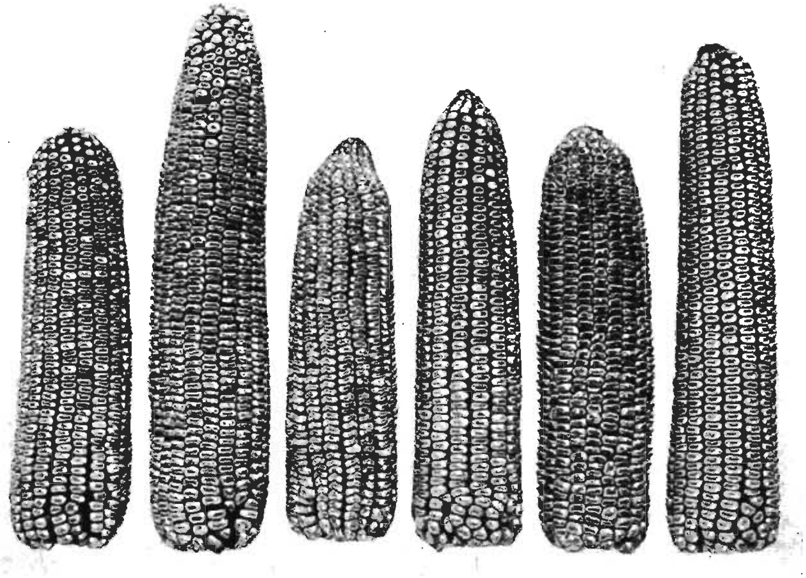
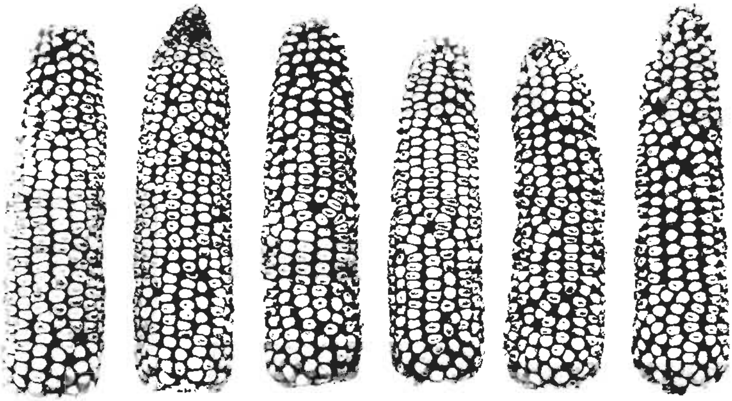


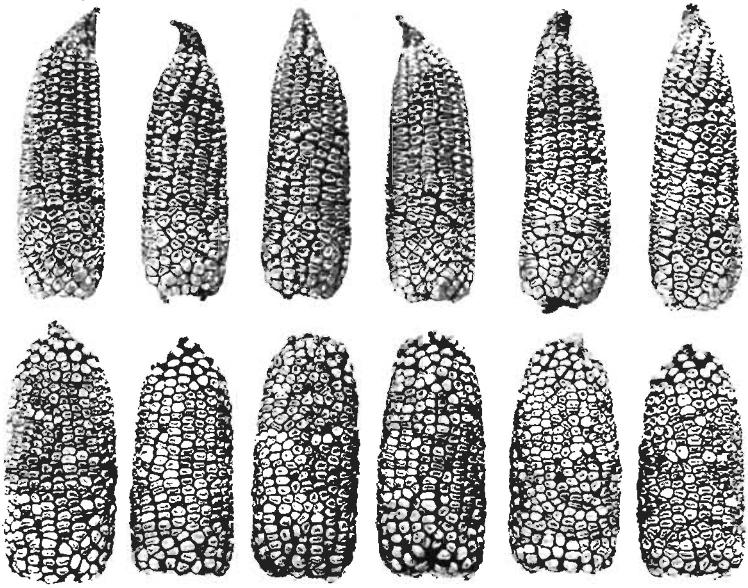
a. A non-inbred variety of Leaming dent corn.

b. Four inbred strains derived from the Leaming variety after nine generations of self-fertilization showing an ear, a cob and a cross-section of a cob of each.

PLATE II.



a. Representative ears of inbred strain No. 1-6-1-3, etc.



b. Representative ears of inbred strain No. 1-9-1-2, etc., above and No. 1-7-1-1, etc., below.

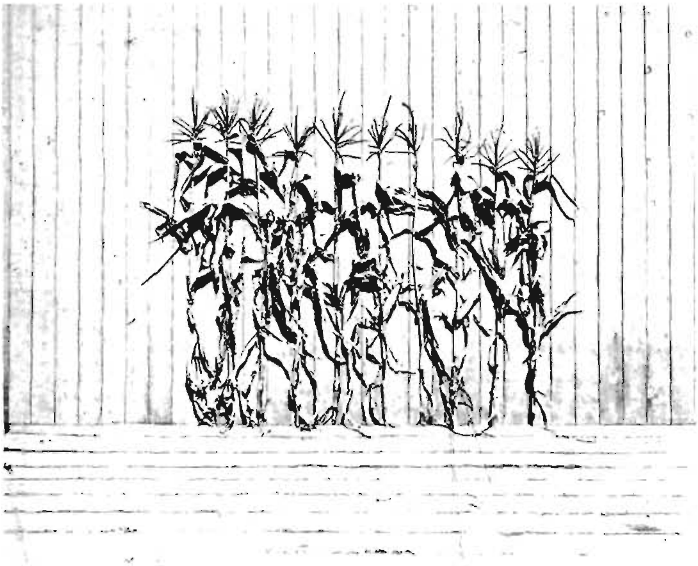
a Representative ears of inbred strain No. 1-7-1-2, etc.

b. The first generation cross of inbred strain No. 1-6-1-3 by 1-7-1-2.

(Plates I to III inclusive, with the exception of Ib, are on the same scale). The plants which produced these ears were all grown on the same field and the non-inbred variety and the first generation cross were grown in adjoining rows. The ears of these latter two represent the best ears produced by 60 plants of each.

a. Representative plants of the original, non-inbred Leaming variety.

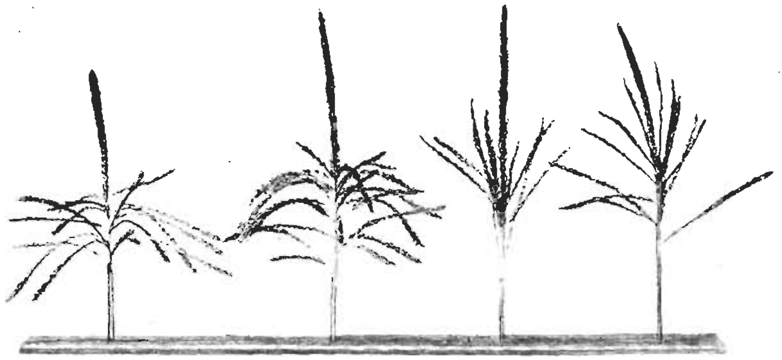
b. Representative plants of the inbred strain No. 1-6-1-3, etc.



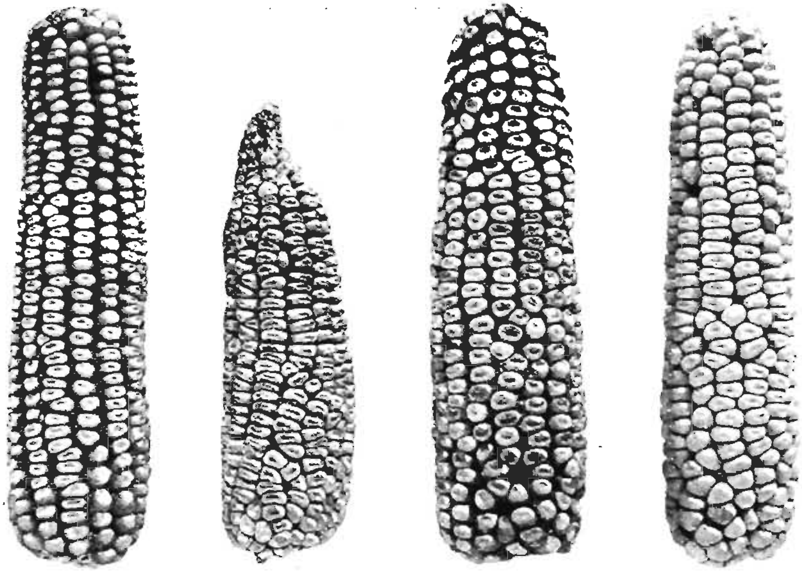
a. Representative plants of the inbred strain No. 1-7-1-2, etc.

b. Representative plants of the first generation cross of inbred strain No. 1-6-1-3 by 1-7-1-2.

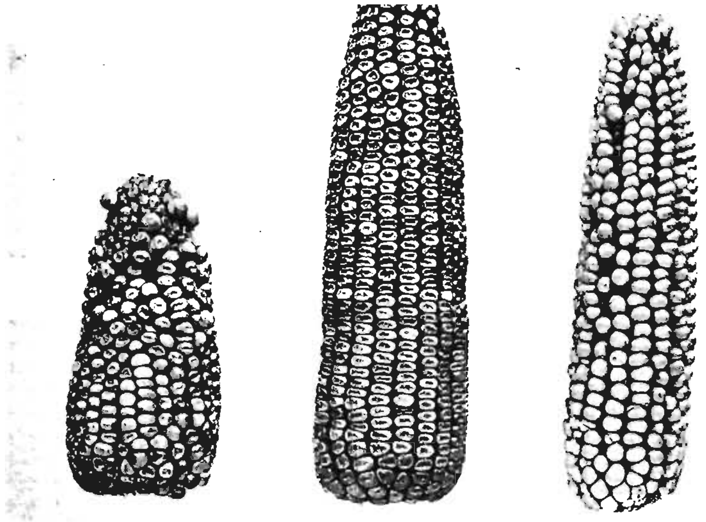
(Plates IV and V are on the same scale.)



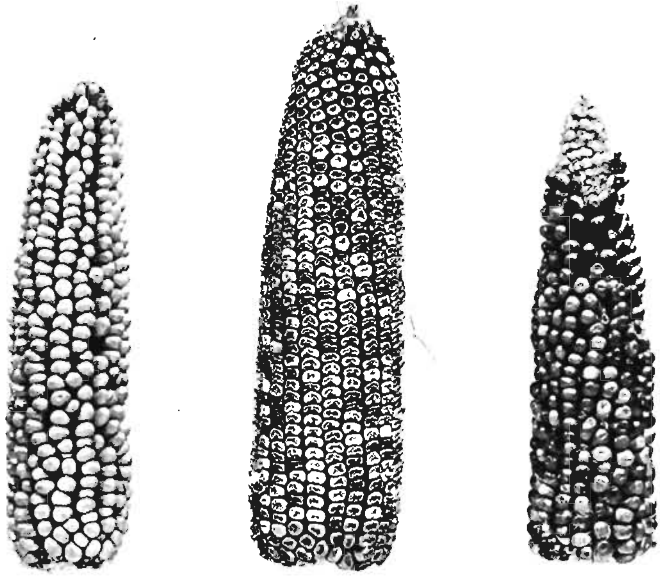
a. Two fully developed tassels on the left and two partially sterile tassels on the right characteristic of four different inbred strains of maize. From left to right they are, 20A-8-5-10; 1-9-1-2; 1-6-1-3; 21-3-13-9.



b. Representative ears from the corresponding strains shown in the illustration above. The first strain on the left produces fully developed tassels and moderately developed ears. The second produces the best developed tassels and the poorest ears. The other two have poorly developed tassels and moderately well developed ears.

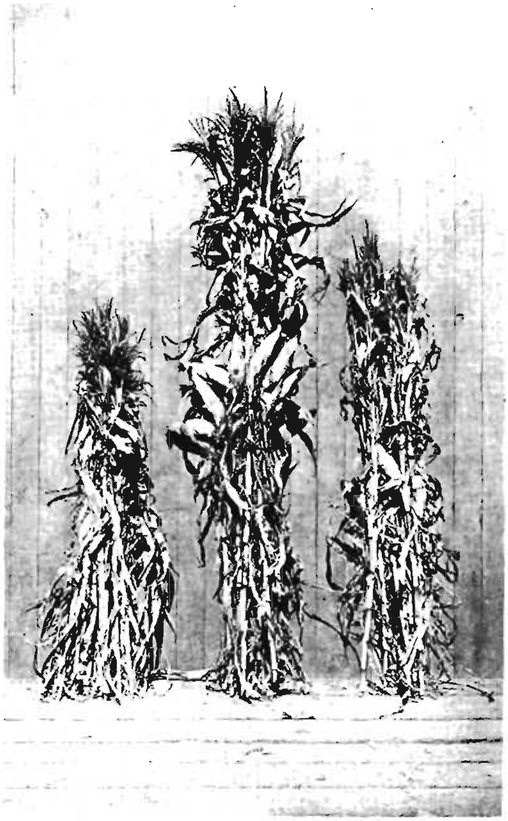


a. Two inbred strains of dent corn, No. 1-6-1-3 at the right and No. 1-7-1-1 at the left and the first generation cross in the center. The three ears were grown under equal conditions and gathered on the same day to show differences in maturity.

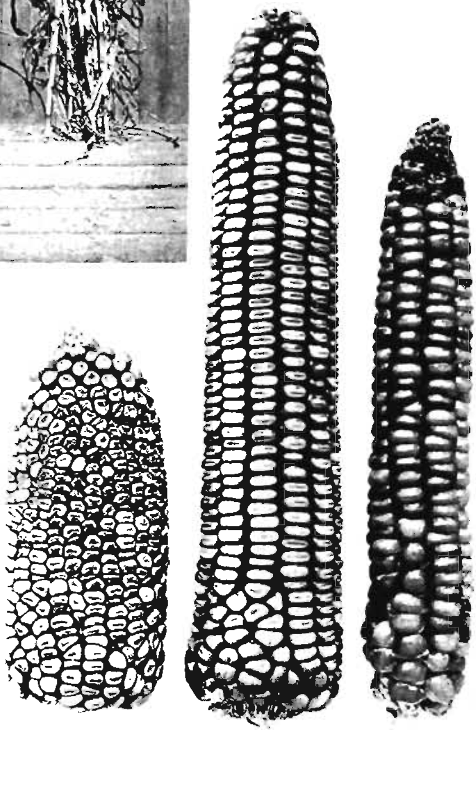


b. Two inbred strains of dent corn, No. 1-7-1-2 at the right and No. 1-6-1-3 at the left and the first generation cross in the center showing the differences in maturity.

PLATE VIII.



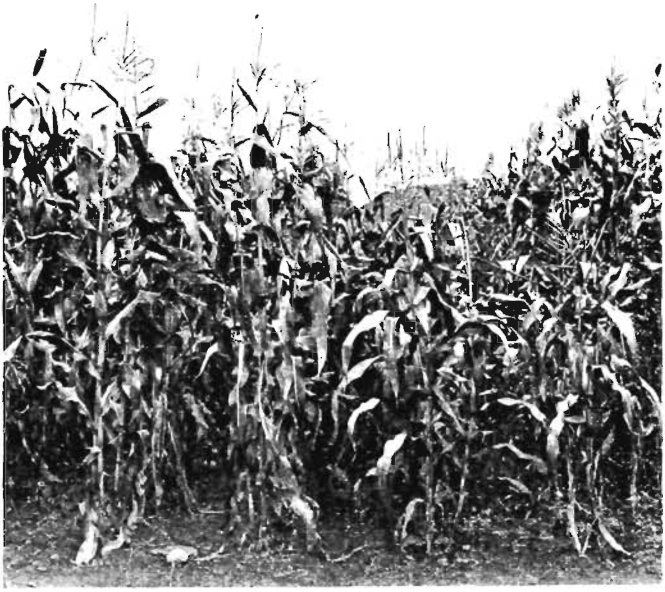
a. Two inbred strains of dent corn, No. 1-6-1-3 at the right and No. 1-7-1-2 at the left, and their first generation cross.



b. An inbred flint and an inbred dent corn compared with the first generation cross.

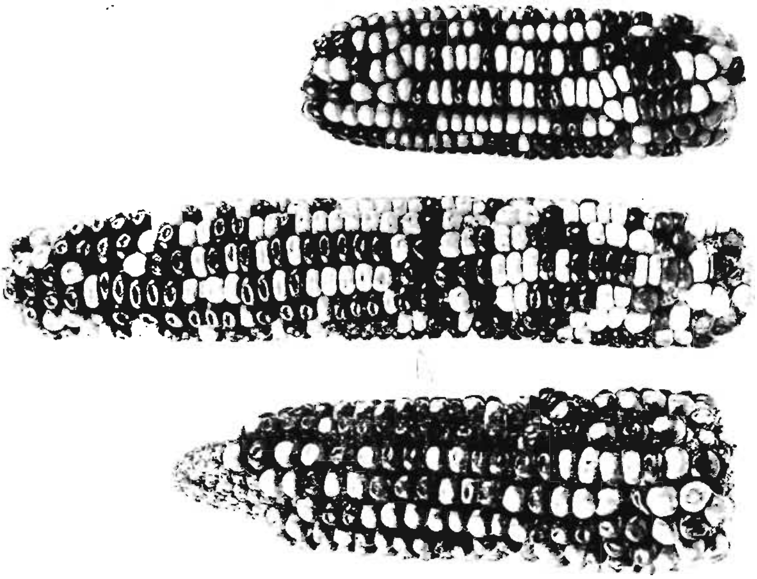
a. Seeds of two inbred strains of corn and the seeds produced upon the first generation hybrid plant in the center. The second generation plants grown from these large seeds have an advantage over either the parents or the first generation hybrid.

b. Two inbred strains and their first and second generation hybrids. From right to left they are: inbred strain No. 1-9-1-2, No. 1-7-1-1, (1-9 x 1-7) F_2 and F_1.



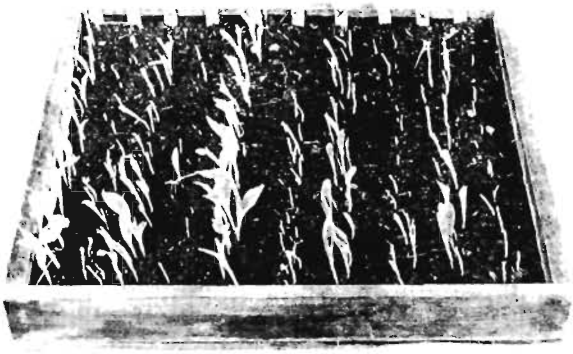
a. The same two inbred strains and their first and second generation hybrids as in IX b. From right to left they are: inbred strain No. 1-9-1-2, No. 1-7-1-1, (1-9 x 1-7) F_2 and F_1.

b. Same as above—ten plants of each.



a. Selfed, reciprocally crossed and out-crossed seeds obtained by pollinating plants of three different strains with a mixture of yellow and white-carrying pollen from the plants which bore the two ears shown below, showing the ratio and distribution of the two different kinds of seeds produced on each ear.

(The seeds resulting from the "yellow" pollen were colored by hand on all three ears.)



b. Seedlings showing the rate of growth and the amount of germination of selfed and crossed seeds from the same ears from five different plants.

a. The first generation cross of an inbred strain which lacks brace roots but has the habit of branching freely from the base of the plant (shown at the right) with an inbred strain (shown at the left) which has well developed brace roots but does not branch at the base. The three lots of plants have resulted from three seeds each.

b. A closer view of the roots of the plants shown in the above illustration.

Connecticut Agricultural Experiment Station

NEW HAVEN, CONN.

BULLETIN 208 OCTOBER, 1918

ENTOMOLOGICAL SERIES No. 26.

Insects Attacking the Potato Crop in Connecticut

By W. E. BRITTON.

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Insects Attacking the Potato Crop in Connecticut.

By W. E. Britton, *State and Station Entomologist.*

As a rule potatoes in Connecticut are not greatly injured by insects, and remedial measures are seldom required other than to apply lead arsenate to control the Colorado beetle.

In certain seasons, however, other chewing insects will cause some damage. Thus in 1918 the potato flea beetle was abundant throughout the state and perforated the leaves, considerably weakening the plants and injuring the crops. Also the three-lined potato beetle and one of the tortoise beetles were common and of course did some damage.

Cutworms, wireworms, blister beetles, white grubs and the stalk borer all take an occasional toll from the harvest of the farmer. Then in some localities in certain seasons sucking insects, especially aphids, may attack and seriously injure the crop as was the case in 1917 and 1918.

The object of this bulletin is to bring together in a form convenient for ready reference, brief descriptions and illustrations of both the common and the uncommon insect pests of the potato in Connecticut and to recommend control measures, so that the grower may have a guide which may be safely followed. Most of the insects mentioned, will readily be recognized by comparing with the accompanying illustrations (plates XIII-XX) which are essentially a part of this bulletin.

CHEWING INSECTS.

All pests grouped under this heading gnaw away parts of the plant, and those which feed upon the leaves can usually be controlled by arsenical poisons.

Potato Flea Beetle.

Epitrix cucumeris Harris.

This is a small, black, jumping beetle about one-sixteenth of an inch in length. The antennae and legs are yellowish, but the head

thorax and wing-covers are jet black. There is a deep transverse groove at the base of the thorax, and the wing covers are microscopically pitted lengthwise in rows, and bear minute gray hairs. (See figure 1.) Other species injure the potato in the Southern and Western states, but in Connecticut, the attacks observed were due to *E. cucumeris* sometimes called the cucumber flea-beetle, though it more commonly injures the potato. It is usually the first insect to attack the potato vines as soon as they come up. The beetles jump quickly when disturbed and eat small holes from the under side of the leaves, soon perforating them. In many cases the feeding does not extend through the leaf but appears as a blister-like injury on the lower surface. Flea-beetle injury is shown on plate XIII, a.

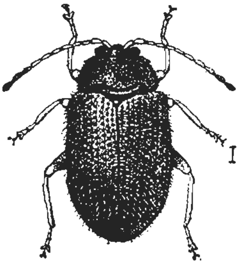

Figure 1. The cucumber flea beetle *Epitrix cucumeris*, greatly enlarged. (After Chittenden, Bureau of Entomology, U. S. Department of Agriculture.)

The beetles hibernate under rubbish and leaves, and the eggs are laid in May or June. The larvae are slender thread-like white worms, which live, and transform in the ground, feeding upon the roots and tubers. Many tubers from the writer's garden where the flea-beetles were very abundant, had small pin-holes extending inward from the surface sometimes as far as half an inch, where the slender larvae had mined, causing imperfect or "pimply" potatoes. The potato flea-beetle has not been carefully studied in Connecticut but it is generally considered that there are two and perhaps three generations each year.

Control Measures: Flea-beetles may be killed by arsenical poisons, trapped by mechanical devices, or driven away by repellants.

Thoroughly coating both upper and under surfaces of the leaves with a heavy spray of lead arsenate (1 lb. in 5 gallons water) will

usually prevent injury. In some experiments a few years ago, tomato and tobacco plants were dipped in this poison before being set in the field, and these plants were not injured though untreated plants close by were badly eaten.

When abundant as in 1918, the absolute control of this insect is difficult and not wholly successful. Several growers reported that they had sprayed as carefully and as thoroughly as seemed possible, yet there were just as many beetles as ever. Be that as it may the beetles are difficult to control by poisoning, because they jump about and feed but little in one place. In the ordinary spraying operations, there are plenty of places where the leaves are not covered with poison, and in such places the flea-beetles can feed unharmed. For under-spraying it is necessary to use extension rods bent at an angle of about forty-five degrees near the nozzle.

Bordeaux Mixture is often recommended as a remedy for flea-beetles; it is only a repellant, however, and does not kill them. Wherever Bordeaux Mixture is used to prevent blight, this mixture containing lead arsenate can and should be applied to check flea-beetles rather than to prepare a different mixture.

On account of their jumping habits, flea-beetles may be caught in "tanglefoot" or other sticky materials and thus be greatly reduced in numbers. A few years ago Professor C. L. Metcalf of the Ohio State University, devised and used an apparatus which has since been described.* Briefly, his device consisted of a soap box with cover, the front end removed, nearly half of the central part of the bottom and a good-sized notch in the lower side of the rear end cut away. The inside of this box was coated with "tanglefoot" and when it was pushed forward along the row the flea-beetles on jumping when disturbed were caught in the sticky material. Modifications were suggested, and wires were introduced to keep the foliage from contract with the "tanglefoot." The box was mounted on wheels so that one man could manipulate it, and it caught flea-beetles at the rate of over 25,000 per acre, most of them being stuck on the lower ledges of the box. Professor Metcalf suggests the possibility of using trays containing kerosene or a heavier oil in the place of these ledges, because the trays could easily be emptied. It was necessary to stop occasionally and remove the beetles and apply more "tanglefoot."

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* Journal of Economic Entomology, Vol. 8, p. 240, 1915.

Possibly some device of this sort may solve the problem of controlling flea-beetles, in seasons when they are unusually abundant, and when the success of spraying is questionable.

Colorado Potato Beetle.

Leptinotarsa (Doryphora) decemlineata Say.

For many years this insect has been regarded as the chief insect enemy of the potato crop, and it more than any other single species is responsible for the development of the use of arsenical poisons—Paris green for many years being the only poison used.

The Colorado beetle is a native of the Rocky Mountain region of the Southwest, where it fed upon the indigenous plants of the

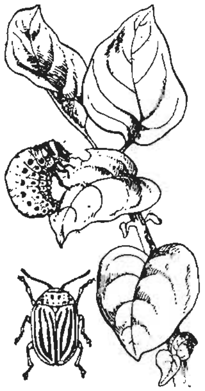


Figure 2. Colorado potato beetle; larva and adult. Natural size.

potato family. As the country gradually became settled, and each pioneer pushed westward a little beyond his neighbor and planted his patch of potatoes, there came a time about 1855 when the frontier of potato growing reached the region where these beetles were native, and they began to feed upon the potato foliage. These potato patches like rungs of a ladder made excellent stepping places in the eastward progress of the beetle. About 1864 it crossed the Mississippi River and in about 1874 it was first recorded along the Atlantic seaboard. At first, hand-gathering was the remedy and it was predicted that farmers must give up growing potatoes. Soon it was found that Paris green would save the vines and kill the insects. Thus for nearly fifty years, potatoes have been grown and the Colorado beetle held in check by the use of arsenical poisons.

The eggs are bright yellow and are laid on the under side of the leaves in clusters of about a dozen as shown on plate XIV, b, and hatch in about a week. One female lay from 500 to 1,000 eggs. The adult is a yellow beetle about three-eighths of an inch long, with five black stripes running lengthwise on each wing-cover and a series of black spots on the thorax. The larva is a stout, fleshy grub reddish in color with black head and marked with black spots as shown on plate XIV, a. Both adult and larvae are shown in figure 2.

The adults appear in early spring and are ready to feed upon the first potato leaves to show above ground. The larvae require about three weeks to reach maturity when they go into the ground to pupate. Probably there are two and sometimes three generations each year, the winter being passed in the ground as pupae or as adults.

Perhaps the most important insect parasites of the Colorado potato beetle in Connecticut are the two-winged flies belonging to the family Tachinidae. Two species have been reared from larvae and identified as *Doryphorophaga doryphorae* Riley, and *D. aberrans* Town.

Several predaceous insects feed upon the eggs or larvae of the Colorado beetle; among these are the lady beetles which devour the eggs and small larvae, the ground beetles especially *Lebia grandis* Hentz, and the soldier bugs, particularly the spined soldier bug, *Podisus maculiventris* Say.

Turkeys, crows, and red-breasted grossbeaks feed somewhat on the Colorado potato beetle.

Control Measures: Spraying the foliage with an arsenical poison is the most satisfactory means of control in the field. For nearly fifty years Paris green was used for this purpose, but it has now been superseded nearly everywhere by lead arsenate.

Arsenate of lead is safer than Paris green and adheres better to the foliage. It contains less arsenic and therefore requires more per barrel to kill the beetles. It is made in both the dry or powdered form, and in form of paste containing 50 per cent. water. Usually it is applied as follows:

Lead arsenate (paste)..............	**3 lbs.**
Water	**50 gals.**

Instead of the paste, the dry form may be substituted using half as much by weight or one and one-half pounds. It may also be sifted or blown upon the wet plants without being mixed with lime or any other diluent. This poison may also be added to Bordeaux Mixture or nicotine solution without injury to the foliage providing soap is omitted.

Paris green is a powerful poison in the form of a dry powder. It may be mixed at the rate of 1 lb. in 100 lbs. with land plaster or air-slaked lime and dusted or blown upon the wet plants or applied as a spray using from one-third to one-half pound in 50 gallons of water. As Paris green contains some free arsenic in acid form there is always danger of burning the leaves with it unless lime is added to take care of the free acid. A good formula for making the spray is as follows:

Paris green	½ lb.
Quick lime	2 lbs.
Water	50 gals.

The lime should be slaked before adding to the mixture. The poison may be used in combination with Bordeaux Mixture without additional lime as the Bordeaux Mixture contains an excess of lime. Though Paris green may be used successfully, as it has been used for many years, it will wash off with the first heavy rain unless Bordeaux Mixture or some other good adhering agent is present.

During the past few years, several arsenical poisons have been tested in the field, and some even have been placed upon the market. Arsenite of zinc is one of these tested in Connecticut a few years ago. Arsenate of lime is a more recent acquisition, which is made in dry or powder form. It is very fine and light, and remains well in suspension. It was considerably cheaper in 1918 than lead arsenate. When used there should be an excess of lime present to prevent burning. A spray mixture containing Bordeaux already has lime in excess, so that additional lime is unnecessary. In the small home garden, the beetles may be gathered by hand and destroyed, especially where on account of children or domestic animals it seems undesirable to use poison.

As a rule the adult beetles emerge from the ground early in May and attack some of the potatoes as soon as the plants appear. Later the larvae also appear on certain plants here and there scattered over the field. At this time of the season lead arsenate is about the

only spray material required. The plants are small and if a power sprayer is used most of the material will strike the ground and consequently be wasted.

Probably the most economical treatment is to send a man through the field with a compressed air sprayer (or with duster or powder gun if the dry poison is used) and poison only those plants where the insects are feeding. Later when the larvae are more abundant and most of the plants are being injured, all should be sprayed.

As the blight does not start until about July 1st, Bordeaux Mixture may be withheld until the latter part of June: then the foliage should be kept covered as long as the plants are making growth and lead arsenate should be added to the Bordeaux as long as there is danger from leaf-eating insects.

The traction power sprayers often used in potato fields are generally unsatisfactory (1) because they do not apply enough liquid (2) because they treat all plants alike whether infested or not. If an outfit is used which does not depend upon traction for power, it is possible to stop and spray for a few minutes, in order to thoroughly coat the plants in certain sections of the field where the infestation is heaviest.

A gasoline engine will furnish power for larger operations, and a hand pump like that shown on plate XIII, b, will answer nicely for small fields.

Three-Lined Potato Beetle.

Lema trilineata Oliv.

This beetle is yellow with three black stripes running lengthwise and resembles the striped cucumber beetle but is larger, and the thorax is constricted and marked with two black dots. The eggs are yellow and resemble those of the Colorado beetle, but are smaller and are more apt to be attached to the midrib of the leaf instead of promiscuously in clusters. They are shown on plate XV, a. Both kinds are laid on the under side one end of each egg being attached to the leaf.

The larvae usually line up in a row side by side on the under surface and devour the leaf working from the tip toward the base and leaving the larger veins. The larvae are buff or tan in color, but are partly covered by their own black or brown excrement, giving them a very disgusting appearance. Eggs, adults and larvae are shown on plate XV.

There are two generations each year, the larvae appearing in June and in August, and the winter is passed in the pupa stage. This insect was more abundant in 1918 than the writer has ever seen it in Connecticut. The same arsenical poison that is used against the Colorado beetle, will control the three-lined beetle.

Tortoise Beetles.

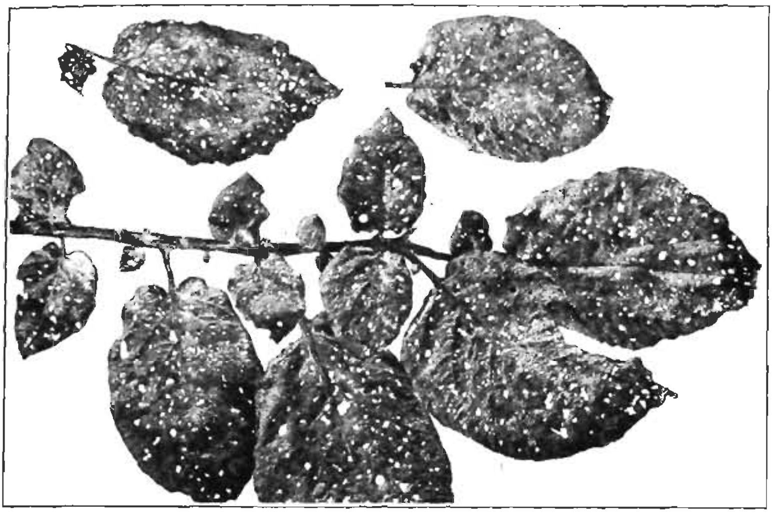
Occasionally potatoes are attacked by small hemispherical beetles having a rather conspicuous marginal flange, known as tortoise beetles. They feed upon the wild morning glory or bindweed and also upon the sweet potato. There are at least three species in Connecticut belonging to the genus *Coptocycla*. *Coptocycla bicolor* is of a beautiful irridescent gold color in life often with inconspicuous black spots. It is sometimes called the "gold bug" or "gold beetle." The other two species *C. clavata* Fabr and *C. guttata* Oliv are both brown on the back with the marginal flange translucent. In *C. guttata* the dark portion is more or less translucent spotted. *C. clavata* is larger with the brown area very rough. This species is shown on plate XVI, a, and was quite prevalent in Connecticut in 1918, being observed in New Haven and Mount Carmel and was received from Clinton, Guilford, Meriden, Monroe, Plainville, and Shelton.

The eggs are laid singly on the veins or stems of the leaves, each egg being covered with a small mass of black excrement. The larvae are dull green, oval, flattened, with lateral projections or spines, and feed upon the under surface of the leaves. They carry their excrement on the caudal spines. There is only one generation each season and the winter is passed in the adult stage, the beetles hiding in crevices and appearing on the potato plants during the month of May.

Though this beetle feeds upon the potato leaves, it probably does not cause very great damage, and may readily be controlled by the arsenical poisons.

The Blister Beetles.

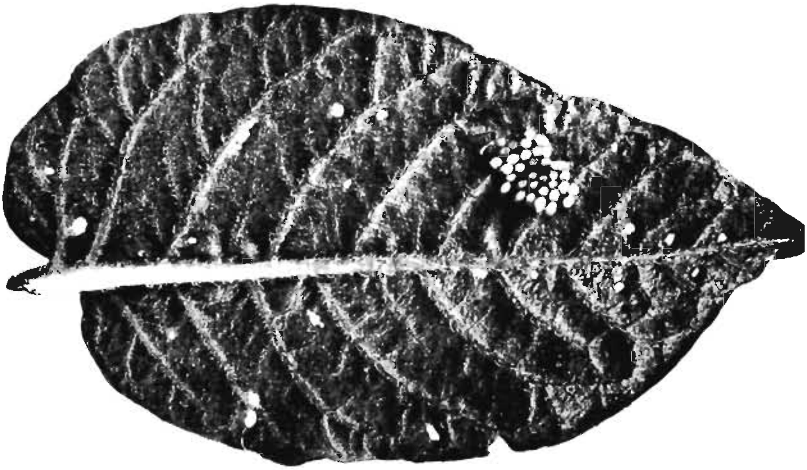
There are several species of blister beetles which may be found feeding upon the potato in Connecticut. These are about half an inch long, less than half as broad, and with soft wing covers. They fed upon potatoes long before the advent of the Colorado beetle and are some times called "old-fashioned potato beetles." Their attacks



a. Potato leaves injured by *Potato Flea Beetle*, considerably reduced.

b. A good hand-power spray outfit for a potato field of two or three acres or less.

a. Larvae nearly full grown feeding upon leaves. Natural size.



b. Eggs, twice natural size.

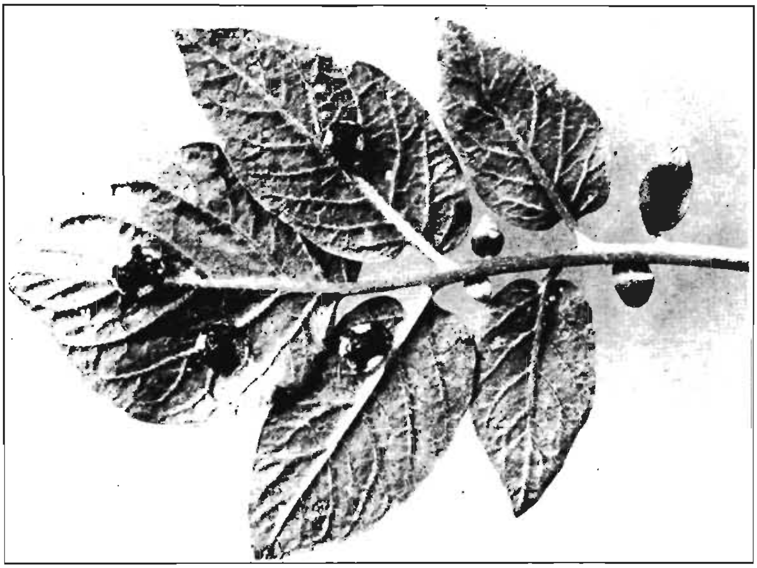
COLORADO POTATO BEETLE.

a. Larvae feeding upon leaf, natural size.

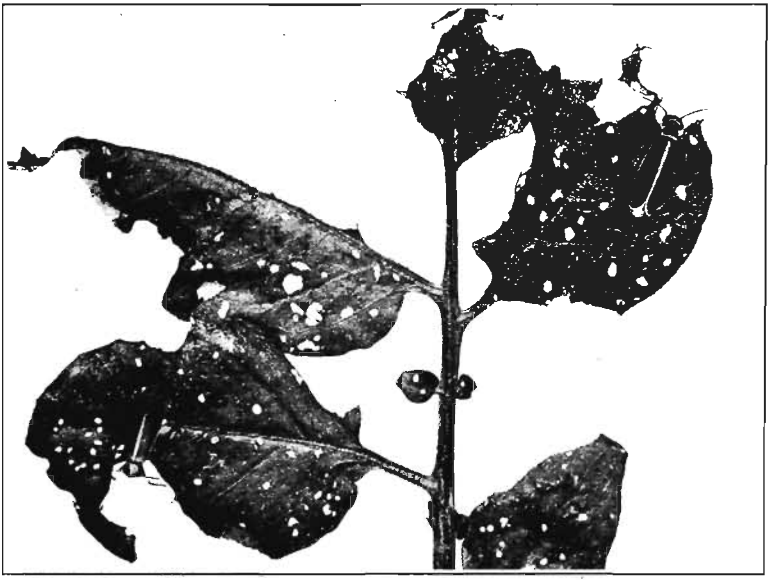
b. Cluster of eggs, natural size.

c. Adults on leaf, natural size.

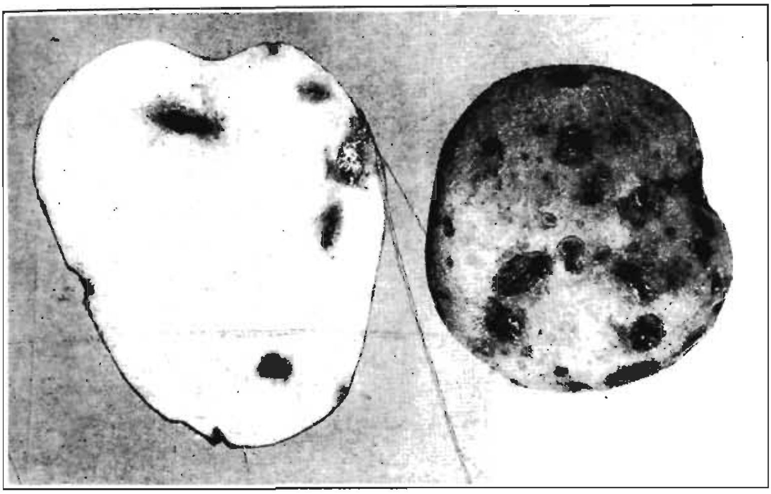
THREE-LINED POTATO BEETLE.



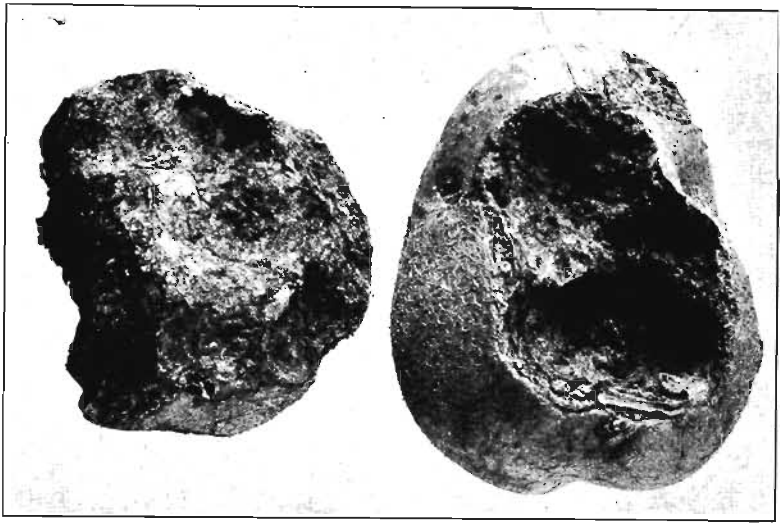
a. Clavate Tortoise Beetle, adults on leaf, natural size.



b. Margined Blister Beetle, adults feeding on leaves, natural size.

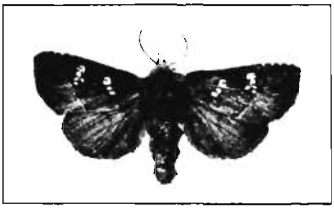


a. Potato tubers injured by wireworms.

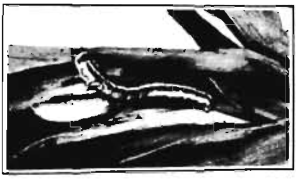


b. Potatoes eaten by white grubs.

PLATE XVIII.



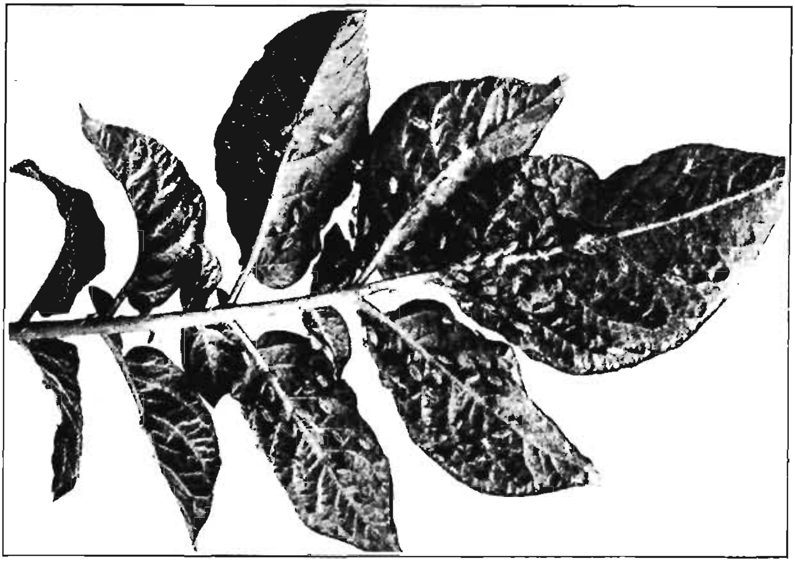
a. Adult of Stalk Borer, natural size.



b. Immature Stalk Borer in corn, natural size.

c. Potato Shoot infested with Potato Aphid, natural size.

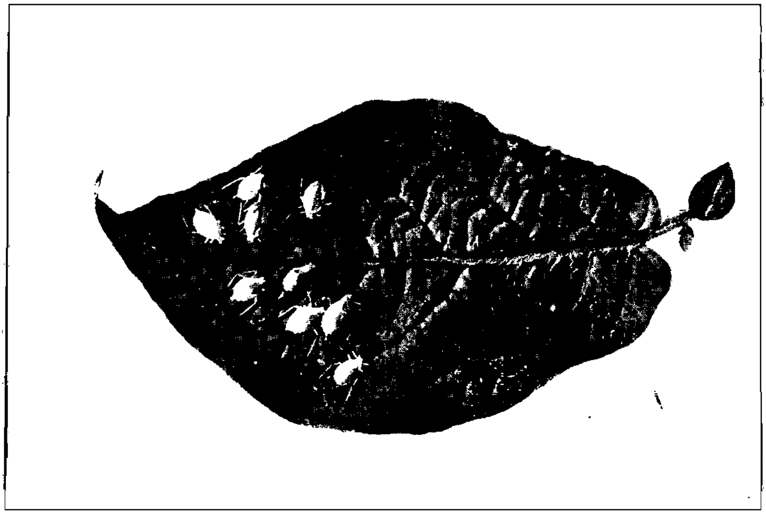
a. Infested blossom stems, natural size.



b. Aphids on the under side of the leaves, natural size.

POTATO APHID.

PLATE XX.



a. Parasitized aphids on upper side of leaf, natural size.

b. Four-Lined Leaf-Bug and its injury to potatoes. Leaves reduced. Bug about natural size.

are by no means confined to the potato but may include nearly any of the garden vegetables or flowers.

The principal species are the black blister beetle *Epicauta pennsylvanica* Degeer, the margined blister beetle *E. marginata* Fabr., the striped blister beetle *E. vittata* Fabr. and the ash gray blister beetle *Macrobasis unicolor* Kby., all of which occur in great numbers in certain seasons, and all of which occasionally feed upon potatoes. These beetles are common on flowers of golden rod in late summer. The margined blister beetle is shown on plate XVI, b.

The larvae of blister beetles do not feed upon potato foliage like the adults but as they devour the eggs of the grasshopper they must be regarded as beneficial.

Wherever blister beetles are injuring potato plants they may be controlled like any other leaf-eating beetle—by an application of lead arsenate.

The Stalk Borer.

Papaipema nitela Guen., and other species.

Potato stalks are often noticed which have been tunnelled up and down inside, and a dirty white larva striped lengthwise with brown and a darker saddle about one-third of its length from the head is found in the burrow. This is commonly known as the stalk borer and is supposed to be *Papaipema nitela* Guen., but there are many species, and several new ones have been described during the past few years by Mr. Henry Bird of Rye, N. Y.

Some of these insects are restricted in their food, a species being found only in one kind of host plant. But not so with *P. nitela,* which attacks many different kinds of plants, including most of the common vegetables and field crops, and many of the flowers and weeds. In fact it may tunnel in almost any herbaceous stem, especially those of larger size. It is often a serious pest of tomatoes, potatoes, corn, dahlias, lilies, etc. Corn was much injured by it in Connecticut in 1918. The writer has often found it in ragweed and during 1918, found a larva boring in a young melon plant close to the ground.

There is only one generation each year, the winter being passed as a pupa in the soil. The adult is a purplish-gray moth having a wing-spread of about one and one-fourth inches. A common form, var. *nebris,* has the fore wings marked with white spots as shown on plate XVIII, a. The larva is about one and one-half inches long

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when fully grown, and has the appearance shown on plate XVIII, b. No control measures can be recommended other than destroying the infested stalks when noticed.

Cutworms.

Like any other vegetables, potato plants are often attacked by cutworms and the stems eaten off near the ground. Cutworms are the larvae of noctuid moths, and there are several species, three or four perhaps being responsible for most of the injury. A common species is shown in figure 3. There is one generation each year, the moths emerging and the eggs being laid the latter part of summer. The cutworms become partially grown before winter then go deep into the soil to remain during the cold weather. Their native food consists of the weeds and grasses. In the spring when

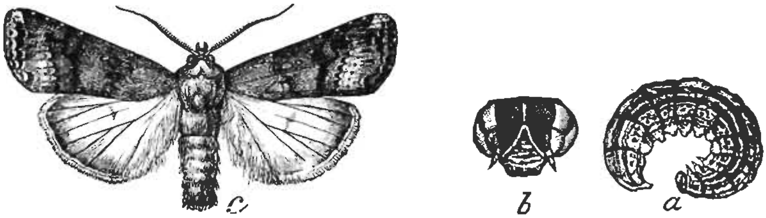

Figure 3. Black cutworm *Agrotis ypsilon*. (After Howard, Bureau of Entomology, U. S. Department of Agriculture.)

warm weather comes they appear to be hungry after their long fast, and cannot resist attacking the tender vegetable plants.

In large fields where cutworms are destructive a poisoned and sweetened mash made of bran should be employed. The following formula will serve:

Wheat Bran	5 lbs.
Paris green or white arsenic	5 ozs.
Lemon or orange	1 fruit.
Molasses	1 pint.
Water	7 pints.

Mix the dry poison and bran together. Squeeze the juice from the lemon or orange into the water, and then cut the pulp and peel into fine pieces and add to the water: then add molasses and stir. Mix this syrup thoroughly with the poisoned bran. This will make a rather dry mash, which may be scattered thinly over the field at

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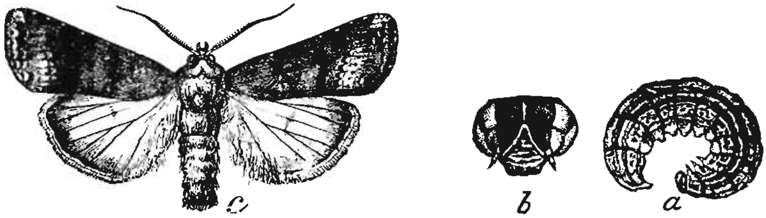

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the time when the first injury is noticed or, if tobacco or tomatoes, a few days before the plants are set. If applied just before dark, the cutworms will have a chance to eat it before it dries, the citrus juice and molasses attracting them.

If it is feared that birds or poultry will partake of the poison, a spoonful may be placed in a hole, here and there and covered with a stone, or a bit of board.

Late fall plowing uncovers many cutworms, thus exposing them to birds and other natural enemies. Extremely thorough harrowing will kill many of them.

If one has only a few plants, these may be protected by wrapping the stems with paper or cardboard.

WIREWORMS.

Wireworms are the larvae of "click" or "snap" beetles and belong to the family Elateridae. There are several species which injure cultivated crops, most of them belonging to the genera *Agriotes, Melanotus* and *Drasterius*. They are small, hard, cylindrical larvae, and are usually tan or reddish-brown in color. They are usually more troublesome in sod land and first bore into the seed tubers, then tunnel into the main stem of the plant just below the surface of the ground, occasionally causing considerable damage in early summer. Later in the season they tunnel into the tubers, causing the injury shown on plate XVII, a, particularly in the "scabbed" areas greatly injuring the appearance and market value as well as the real value of the tubers for food. From three to five years are required for wireworms to go through their complete life cycle, and all stages except the adult are spent in the soil. They are usually more abundant and therefore more troublesome in sod land than in old ground. Crop rotation should be practiced. Where possible plow sod land in the fall and harrow at frequent intervals before the ground freezes. Where wireworms are abundant potatoes should be dug as soon as ripe as they will be seriously injured if allowed to remain for several weeks in the ground.

WHITE GRUBS.

Like wireworms and cutworms, white grubs feed naturally in grass lands and are responsible for much injury to crops,—especially in certain seasons and when planted on sod land. White grubs are the larvae of the May or June beetles belonging to the

genus *Lachnosterna* of the family Scarabaeidae. There are some fifteen species occurring in Connecticut, but as *Lachnosterna fusca* Froh., *L. crenulata* Forst., *L. hirticula* Knoch., *L. nova* Smith and *L. fraterna* Harris, are some of the commoner kinds, it is to be supposed that they are responsible for the damage.

The life cycle of our chief species requires three years for its completion. The eggs are laid in the soil at a depth of from one to eight inches late in May or early in June, and are white and about one-tenth of an inch long. The young grubs feed on decaying vegetation but early eat the roots of living plants. They do their greatest damage in the second year of their larval existence, but may be destructive to early plantations in the spring of their third season.

Figure 4. White grub. Natural size.

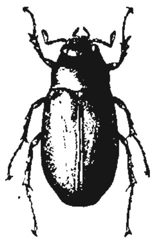

Figure 5. June beetle, adult of white grub. Natural size.

Certain seasons are remarkable for the widespread damage caused by white grubs. Thus there was much injury in Connecticut in 1915, and warnings were isuued to the effect that grubs might be expected in 1918. As a matter of fact, white grubs were reported as doing damage in a few localities in 1918, but it was not as serious as in 1915.

Much of the injury is done to grass land, but when infested grass land is plowed and planted to potatoes, the grubs will often cause serious injury to the crop by eating off the roots of the plants, and also eating into the tubers.

A white grub is shown, natural size, in figure 4, the adult beetle in figure 5, and an injured potato on plate XVII, b.

There are several parasites of white grubs, including wasps of the genera *Tiphia* and *Elis,* and the two-winged flies *Pyrgota undata* Wied., *P. valida* Harr, *Promachus fitchii* O. S. and P. *vertebratus* Say. All except the last occur in Connecticut.

Of the many vertebrates destroying white grubs and their adults, the larger birds, farm fowls, and skunks are probably the most important.

Control Measures: Crop rotation is one of the methods of forestalling serious injury from white grubs. Fall plowing of infested land before October 10, will expose many of the grubs where they will be eaten by birds. If poultry or swine can be turned upon the plowed field a much larger proportion of the grubs will be destroyed. This land should be disked and harrowed very thoroughly before planting.

If potatoes follow clover or corn in a white grub year they will not be greatly damaged.

As has already been advised in relation to wireworms, if grubs are abundant or troublesome, the potato crop should be dug as soon as the tubers are mature.

SUCKING INSECTS.

Sucking insects do not tear away, masticate and devour any portion of the plant, but suck out the plant juices, and thus obtain their nourishment in liquid form. Each insect, therefore is fitted with a sucking tube known as rostrum or proboscis, which it thrusts into leaf or stem and through it sucks out the sap.

Insects of this kind cannot be controlled with arsenical poisons, but something must be applied that will kill them by contact, and nicotine solution and oil and soap emulsions are used for this purpose.

The Potato Aphid.

Macrosiphum solanifolii Ashm.

Both in 1917 and 1918, this aphid caused considerable damage in the potato fields in the southern half of the state, and an account of the former infestation was published in the Report of this Station for 1917, page 290. This aphid is often called the pink and green potato aphid because some individuals are pink or reddish and others are green. It is shown in figure 6, and occurs commonly on solanaceous plants as well as on rose, beet, squash, lettuce, corn, milkweed, bitter-sweet and many weeds and other plants around the field. During the past 18 years it has been collected a dozen times on several different plants in various parts of the State. The earliest record is June 18, 1901, New Haven, on *Clematis crispa.* Some of

these records were from potato and tobacco, but the insect did not cause any severe or wide-spread injury to the potato crop until 1917, when it damaged fields in every county in the State, and was reported from many localities in New Haven and Hartford Counties. The vines soon died and the crop was light on account of this injury. In 1918, the writer had a better chance to observe the work of this aphid. It was first seen at the Station farm at Mt. Carmel on June 11, a very few individuals (probably stem mothers) here and there on the under sides of the leaves in the northeast corner of

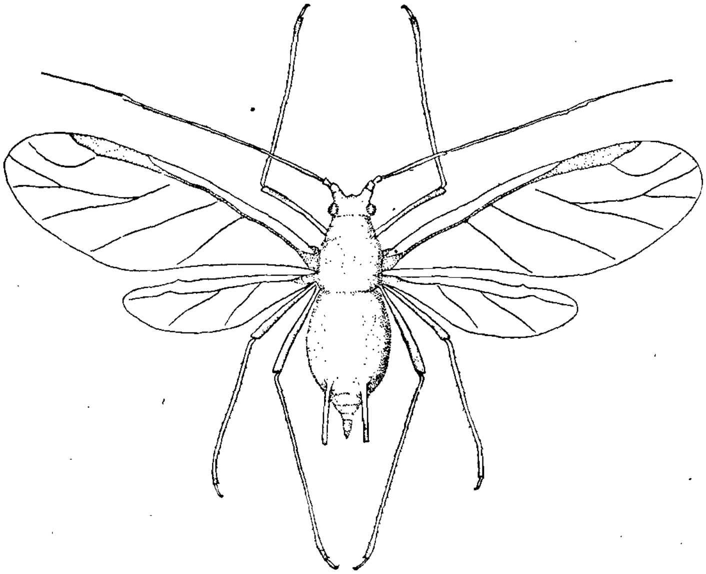

Figure 6. The potato aphid, winged female, summer form. Greatly enlarged.

the field. On June 14, they were more abundant, both pink and green wingless forms being present, and some had begun to produce young.

On June 15, Mr. G. M. Codding observed that potato fields in Greenwich were infested.

On June 20, at the Station farm the aphids did not seem to be any more abundant than on June 14, but a week later (June 27) they had apparently increased, and most of them were on the blossom stems as shown on plate XIX, a. A few occurred underneath

the new leaves at the top of the plants. It seemed advisable to spray, and tests were first made with a number of promising materials which were thought might take the place of soap without the attending danger in the presence of lead arsenate. The field was sprayed however, July 2nd and 3rd with nicotine solution added to Bordeaux Mixture and lead arsenate, using one pint of Black Leaf No. 40 in a barrel (50 gallons) of the mixture. The treatment was not very successful, as the slight wax secretion repelled the spray which rolled off in drops leaving many of the aphids unharmed. Of course a large proportion of them were killed. In three weeks aphids again became so abundant that the field was sprayed again on July 22 and the few days following. By this time many of the topmost leaves were curled and the aphids were very abundant. Nicotine solution had been in great demand, and many retail dealers had sold out. A fresh supply could not be obtained from the factory soon enough to save the crop. Consequently we demonstrated that kerosene emulsion would answer the purpose, at less expense, and the materials could be purchased in any grocery or general country store. The following quantities and materials were used:

FORMULA.

Laundry soap (about 30 oz.)........	3 cakes.
Kerosene	4 gals.
Water	2 "

After churning, dilute eight times to make one barrel (50 gals.)

The soap was cut in thin slices and dissolved in hot water over a fire. It was then removed from the fire and added to the kerosene, and the whole churned violently for a few minutes by passing through a bucket pump with a small hose directed into the same container. This made a uniform, creamy mass, from which the oil did not separate on standing. It was applied with strong pressure, through a fine nozzle and a rod bent at an angle of about 45 degrees near the nozzle by means of which it was possible to direct the spray against the under surface of the leaves.

All the aphids hit by the spray were killed without injury to the plants. They disappeared soon after and no further treatment was necessary.

The more common lady beetles, certain syrphid flies and lacewings feed upon the aphids, and many aphids were parasitized by

a small four-winged parasitic fly, *Aphidius rosae* Halliday, as shown on plate XX, a.

This aphid may be controlled by spraying as above indicated, but in some cases it is practically impossible to spray the under side of the leaves. Brushing the vines just before cultivating will destroy a large proportion of them. A driving rain or heavy down pour is very effective in destroying these aphids at the time of their maximum abundance. The aphids are shown on the blossom stems and on the leaves on plate XIX, also parasitized ones on plate XX, a, and the spraying operations on plate XIII, b.

The Four-Lined Leaf-Bug.

Poecilocapsus lineatus Fabr.

This insect is generally regarded as an occasional pest of small fruits but sometimes also injures garden vegetables and field crops. In 1918, the writer observed several instances of severe injury to certain plants usually near the margin of the field, and close to a woodland or weedy uncultivated field. Injured leaves are shown on plate XX, b.

The four-lined leaf-bug lays its eggs in the soft tender stems of currant and doubtless other plants about the first of July. These eggs are long and slender, somewhat curved, and are crowded together in clusters of six or eight and are pushed end-wise into the soft pith, the outer ends showing as a patch of white.

These eggs hatch the following spring, and about the middle of May the young bugs first appear on the top-most and tenderest leaves. They suck out the green pulp from the under side, leaving roundish semi-transparent spots, which often coalesce. As the insect increases in size it sucks out the pulp from larger areas, and the leaf finally turns brown, dries up and dies. This injury is characteristic, but the insects causing it hide away beneath the leaves and are seldom noticed unless one is hunting for them.

The nymphs at first are bright red marked with black spots but soon change to bright orange-yellow. They pass through five stages in about three weeks, and when mature are winged, nearly one-third of an inch long, bright greenish-yellow, with four black stripes running lengthwise on thorax and wing-covers as shown on plate XX, b.

Probably the best control measure is to spray thoroughly the under side of the top leaves with nicotine solution, two teaspoonfuls in one gallon of water, with one-inch cube of soap dissolved and added, or if a quantity is needed, one pint of nicotine solution and two cakes of laundry soap in 50 gallons of water.

Summary.

The potato crop in Connecticut is injured by a number of chewing insects, the most important being the Colorado Potato Beetle and the Potato Flea Beetle. The Three-Lined Potato Beetle, Tortoise Beetles, Blister Beetles, the Stalk Borer, cutworms, wireworms and white grubs all cause occasional damage. All but the last four may be controlled by spraying with lead arsenate. Cutworms may be destroyed by the use of a poisoned and sweetened bran mash scattered about the field. Against wireworms and white grubs cultural practices are the only remedies.

The principal sucking insect attacking potatoes in Connecticut is the Potato Aphid which can be killed by spraying with nicotine solution and soap, or with kerosene emulsion. The Four-Lined Leaf Bug causes occasional damage and may be controlled by the same sprays as are used against the Potato Aphid.

Information regarding each of these pests and the measures necessary to control them may be found in the foregoing pages, and most of them are shown on plates XIII-XX.

Connecticut Agricultural Experiment Station

NEW HAVEN, CONN.

BULLETIN 209 DECEMBER, 1918

Fertilizer Report for 1918

By E. H. JENKINS, *Director, and*
E. MONROE BAILEY, *Chemist In Charge of the Analytical Laboratory.*

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The Bulletins of this Station are mailed free to citizens of Connecticut who apply for them, and to others as far as the editions permit.

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December, 1918.

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Report on Commercial Fertilizers, 1918.

By E. H. Jenkins, *Director, and* E. M. Bailey,
Chemist in Charge of the Analytical Laboratory.

In 1918, forty-three individuals and firms entered 342 brands of fertilizers for sale in this State, classified as follows:

Nitrogenous superphosphates with potash	132
Nitrogenous superphosphates without potash	151
Bone manures and tankage	24
Fish, castor pomace, chemicals and miscellaneous	35
Total	342

During the spring months Mr. Churchill, the Station's agent, visited about 100 towns and villages in the State and gathered 466 samples. These represented all the registered brands except the following:

Alpha Portland Cement Co.'s Alpha Potash-Lime;* *American Agricultural Chemical Co.'s* Grain and Seeding Fertilizer, Pulverized Sheep Manure, Top Dresser, 1916, Bradley's Tobacco Manure, 1916, East India Economizer Phosphate, 1916, Roanoke Phosphate, 1916, Tobacco Special, 1916, Unexcelled Fertilizer, 1916, Packers' Union Animal Corn Fertilizer, 1916, Potato Manure, 1916, Quinnipiac Wrapper Leaf Brand Tobacco Manure, 1916, Wheeler's Potato Manure, 1916, Williams & Clark's Matchless Fertilizer, 1916, Seed Leaf Tobacco Manure, 1916; *Brown's* Oats & Top Dressing; *Essex* Tobacco Manure; *Fertile Chemical Co.'s* Nitro-Fertile;† *Frisbie's* 4-8-2;‡ *Lister's* Ammoniated Dissolved Superphosphate, Complete Tobacco Manure, 1916, 1-8-2 Fertilizer, Success Fertilizer, 1916; *Lowell* High Grade 5-8; *National* Ammoniated Phosphate, 1916, Extra High Grade Potato Fertilizer, High Grade Top Dressing without Potash; *New England* H. G. Potato Fertilizer; *Parmenter & Polsey's* Special Tobacco & Onion Grower; *Royster's* Pipe of Peace Tobacco

* A sample sent by manufacturer was analyzed.

† A sample sent by manufacturer was analyzed, also one sent by purchaser.

‡ A sample sent by purchaser was analyzed.

Fertilizer; *Worcester Rendering Co.'s* Royal Worcester Corn & Grain Fertilizer.

Of the 31 brands not found on sale, 16 were not sold in the state. Of the remaining 15 brands, 2 manufacturer's samples were analyzed and 1 purchaser's sample was examined.

CLASSIFICATION OF FERTILIZERS ANALYZED.

	Number of Samples
1. *Containing nitrogen as the chief active ingredient:*	
Nitrate of soda	7
Cotton-seed meal	56
Castor pomace	5
2. *Containing phosphoric acid as the chief active ingredient:*	
Basic lime phosphate	1
Precipitated bone phosphate	1
Acid phosphate	13
Barium phosphate	1
3. *Containing potash as the chief active ingredient:*	
Muriate of potash	6
Sulphate of potash	1
Kainit	1
Cotton-hull ashes	5
"Feldspar potash"	1
Potash-Lime Fertilizer	1
4. *Containing nitrogen and phosphoric acid:*	
Fish manures	9
Slaughterhouse tankage	8
Mixed bone and tankage	1
Garbage tankage	1
Bone manures	20
5. *Mixed fertilizers:*	
Nitrogenous superphosphates	267
6. *Miscellaneous fertilizers and waste products:*	
Sheep manure	10
Rabbit manure	1
Bat guano	2
Wood ashes	21
Lime and limekiln ashes	4
Tobacco stems and dust	3
Lime-Fertile and Nitro-Fertile	4
Other miscellaneous materials	76
Total	526

I. RAW MATERIALS CHIEFLY VALUABLE FOR NITROGEN.

NITRATE OF SODA.

The nitrate sold in this State in 1918 has maintained the usual quality having an average content of 15.49 per cent. of nitrogen.

Seven samples were analyzed as follows:

10955. Sold by Berkshire Fertilizer Co., Bridgeport. Old stock of W. H. Burr, Westport.

10708. Sold by Nitrate Agencies Co., New York. Stock of A. G. Ross, Bridgeport.

10709. Sold by American Agricultural Chemical Co., New York. Stock of F. S. Bidwell Co., Windsor Locks.

10870. Sold by Apothecaries Hall Co., Waterbury, Sampled at Factory.

***9714 and 9715.** Stock of Brainard Nursery & Seed Co., Thompsonville.

10710. Sold by Sanderson Fertilizer & Chemical Co., New Haven. Sampled at Station Farm, Mt. Carmel.

ANALYSES OF NITRATE OF SODA.

Station No.	**10955**	**10708**	**10709**	**10870**	**9714**	**9715**	**10710**
Per cent. of							
Nitrogen guaranteed	14.80	15.00	15.00	15.00	....	....	15.00
Nitrogen found	15.20	15.48	15.24	15.35	15.96	15.98	15.24
Cost per ton	$67.66	100.00	100.00	113.00	....	....	....
Nitrogen costs cents per pound	**22.3**	**32.3**	**32.8**	**36.8**	....	....	....

Two of the samples contain at least one-half per cent. more nitrogen than is usually found in this article.

The price of **10955** is not a current price.

The market price of nitrogen in this form during the year has ranged from 32 to 37 cents and even higher.

COTTON SEED MEAL.

Only 56 samples of this material have been sent for analysis, a smaller number than in any other recent year. Of these analyses only those which failed to meet the claims of the seller, eleven in number, are given in table, page 127.

* Not sampled by station agent.

The percentage of nitrogen ranged from 5.12 to 7.02, the average of all samples being 5.98 per cent. The average cost per ton of the 56 samples was $57.41 and in most cases represents deliveries in car lots.

Cotton seed meal contains about 2.9 per cent. of phosphoric acid and 1.9 per cent. of potash. If these are valued at 5 and 30 cents respectively,

the average cost of nitrogen in cotton seed meal in 1918 has been about 36 cents per pound.

The average figures for the last six years have been:

Year.	Number Analyzed.	Cost per Ton.	Per cent. Nitrogen.	Nitrogen Cost cents per Pound.
1913	315	$33.00	6.89	20.7
1914	224	.....	6.77	21.6
1915	182	.....	6.96	19.9
1916	177	39.52	6.65	20.9
1917	95	44.20	6.10	26.5
1918	56	57.41	5.98	36.0

Much less unmixed cotton seed meal has been used as a fertilizer this year in this State. The reasons are several. It was sold on sight draft instead of arrival draft and buyers did not care to assume the risk of over charges in freight, loss from rough handling, etc.

Shortage of labor made the work of home mixing more difficult and led many to use only factory mixed fertilizers.

The higher price and lower content of nitrogen also lessened the demand and freight congestion made deliveries uncertain.

The steady deterioration in the quality of the meal is evident from the figures given above. It may be explained by the facts that because of the high price of cotton, the seed has been closely ginned to secure all the cotton possible, and where the seed is nearly "bald" the removal of the hulls is not so complete as where there is considerable fibre left on them.

It is also stated that the removal of oil is more complete where a larger amount of hull is left with the meal and, finally, there seems to be a tendency to reduce meal generally to a basis of 36 per cent. of protein (5.76 per cent. nitrogen).

At the time of writing, early December, 43 per cent. meal is quoted *in Kansas City* at $67.00 which, with the usual allowance for phosphoric acid and potash, makes nitrogen cost over 38

COTTON SEED MEALS BELOW GUARANTY.

Manufacturer or Jobber, Car No. or Marks.	Purchased, Sampled or Sent by	Per cent. Nitrogen. Found.	Per cent. Nitrogen. Guaranteed.	Cost per ton.
merican Cotton Oil Co., N. Y.				
2401	T. C. Seymour, Windsor Locks	5.50	5.75	$53.56
	Henry Fuller, Suffield	5.60	5.76	53.75
3111	E. S. Seymour, Suffield	5.12	5.75	54.50
32647	T. C. Seymour, Windsor Locks	5.42	5.75	56.03
5040	T. C. Seymour, Windsor Locks	5.56	5.75	56.03
. L. Buss & Co., Boston.				
7384	Geo. S. Phelps & Co., Thompsonville	5.43	5.75	57.50
odney J. Hardy & Sons, Boston.				
1399 M. K. A.	Geo. S. Phelps & Co., Thompsonville	5.49	5.75	58.00
Humphreys-Godwin Co. Memphis, Tenn.				
937, G. C. & T. F.	H. C. Cone, Suffield	5.88	6.18	52.00
3446 L. & W.	H. C. Cone, Suffield	5.50	5.76	57.00
2132 I. C.	H. C. Cone, Suffield	5.99	6.18	52.00
outhern Cotton Oil Co., N. C.				
18869	Griffin Tob. Co., No. Bloomfield	5.50	5.76	53.50

nts per pound at that point. 36 per cent. meal is quoted in nnecticut on the same date at $64.00, making the cost of nitro- n about 43 cents.

CASTOR POMACE.

Five samples were analyzed as follows:

11053. Sold by Apothecaries Hall Co., Waterbury. Stock of . J. Reeves, Windsorville.

10894. Sold by H. J. Baker & Bro., N. Y. Stock of Oliver rall, Windsor.

10864. Sold by A. L. Koster, Suffield. Stock of S. B. Warner, ndsor.

10776. Sold by Olds & Whipple, Hartford. Stock of F. S. Bidwell & Co., Windsor Locks.

11201. Sold by Olds & Whipple, Hartford. Sampled at factory.

10864 was found with no tags attached. The seller reported the nitrogen guaranty.

ANALYSES OF CASTOR POMACE.

Station No.	11053	10894	10864	10776	11201
Per cent. of					
Nitrogen guaranteed	4.52	4.52	4.52	4.50	5.00
Nitrogen found	5.28	4.64	5.10	4.70	4.90
Cost per ton	$58.00	$53.00	$53.50	$57.00	$53.00

The average ton price of these five samples has been $54.90. Their average nitrogen content has been 4.92.

Allowing 5 cents and 30 cents per pound respectively for the phosphoric acid and potash in them, the average cost of nitrogen has been not far from 48 cents per pound, the most expensive form of nitrogen.

The castor pomace situation is as follows: The castor beans formerly imported from India have all gone to England, the castor oil being greatly needed for the lubrication of aeroplane motors. There has been a considerable production of castor beans in this country since our entry into war, but it has had no effect on the supply of pomace in New England.

II. RAW MATERIALS CHIEFLY VALUABLE FOR PHOSPHORIC ACID

BASIC LIME PHOSPHATE.

11052. Sold by American Agri. Chem. Co., N. Y. Stock of E. Dudley Bartlett, Guilford. Cost $23.00 per ton. Guaranteed 13 per cent. "available" phosphoric acid, 14 per cent. total phosphoric acid. It contained

Water-soluble phosphoric acid	1.23
Citrate-soluble phosphoric acid	13.40
Citrate-insoluble phosphoric acid	1.45
Total phosphoric acid	16.06
"Available" phosphoric acid	14.63
Lime	28.30
Magnesia	0.89

"Available" phosphoric acid in this material costs 7.9 cents per pound.

PRECIPITATED BONE PHOSPHATE.

10997. Sold by Olds & Whipple, Hartford. Sampled at factory. Cost $48.35 per ton. It contained

Water-soluble phosphoric acid	2.02
Citrate-soluble phosphoric acid	28.20
Citrate-insoluble phosphoric acid	2.56
Total phosphoric acid	32.78
"Available" phosphoric acid	30.22

"Available" phosphoric acid in this material costs 8 cents per pound.

DISSOLVED ROCK PHOSPHATE OR ACID PHOSPHATE.

Thirteen samples were analyzed as follows:

10890. Sold by Nitrate Agencies Co., N. Y. Stock of A. G. Ross, Bridgeport.

10893. Sold by L. T. Frisbie Co., N. H. Sampled at factory.

11003. Sold by Wilcox Fertilizer Co., Mystic. Stock of M. E. Thompson, Ellington.

10777. Sold by American Agr. Chem. Co., N. Y. Stock of W. J. Lobdell, Stratford.

11018. Sold by Coe-Mortimer Co., N. Y. Stock of J. E. Stoddard, Abington.

11051. Sold by American Agr. Chem. Co., N. Y. Stock of E. H. Latimer, Southington.

10956. Sold by F. S. Royster Guano Co., Baltimore, Md. Stock of J. D. Kelsey & Son, Madison.

11020. Sold by Armour Fertilizer Works, Chrome, N. J. Stock of Quality Seed Store, Stamford.

10866. Sold by American Agr. Chem. Co., N. Y. Stock of Geo. S. Phelps & Co., Thompsonville.

10871. Sold by Apothecaries Hall Co., Waterbury. Sampled at factory.

11162. Sold by Armour Fertilizer Works, Chrome, N. J. Stock of Quality Seed Store, Stamford.

10833. Sold by Bowker Fertilizer Co., N. Y. Stock of W. B. Martin, Rockville.

10957. Sold by Coe-Mortimer Co., N. Y. Stock of Gunther Bros., Rockville.

ANALYSES OF ACID PHOSPHATE.

Station No.	Water-soluble phosphoric acid.	Citrate-soluble phosphoric acid.	Citrate-insoluble phosphoric acid.	Total phosphoric acid.	"Available" phosphoric acid found.	"Available" phosphoric acid guaranteed.	Cost per ton.	"Available" phosphoric acid cost cents per pound.
10890	13.56	2.78	0.47	16.81	16.34	16.0	$21.00	6.4
10893	15.61	1.87	.....	17.48	17.48	16.0	23.00	6.6
11003	15.70	2.85	0.23	18.78	18.55	15.5	27.00	7.3
10777	12.29	3.83	1.57	17.69	16.12	16.0	26.00	8.1
11018	12.12	4.09	1.27	17.48	16.21	16.0	27.00	8.3
11051	15.64	1.22	1.27	18.13	16.86	16.0	29.00	8.6
10956	13.40	3.25	0.79	17.44	16.65	16.0	29.00	8.7
11020	13.73	1.89	0.27	15.89	15.62	16.0	28.00	9.0
10866	10.15	4.16	1.36	15.67	14.31	14.0	26.00	9.1
10871	10.28	3.88	0.99	15.15	14.16	14.0	26.00	9.2
11162	14.03	1.51	0.19	15.73	15.54	16.0	30.00	9.7
10833	12.08	2.32	1.50	15.90	14.40	14.0	29.00	10.1
10957	9.85	4.23	1.07	15.15	14.08	14.0	.....	....

Of these samples **11020** did not meet the guaranty, the deficiency in available phosphoric acid being 0.38 per cent.

Of the twelve samples with cash prices attached 9 are guaranteed 16 per cent. "available" and 3 are guaranteed 14 per cent.

The average cost of the former is $26.33 and of the latter $27.00.

On this basis available phosphoric acid in the higher grade has cost about 7.9 cents per pound and in the lower grade 9.4 cents.

BARIUM-PHOSPHATE.

11019. Sold by Witherbee, Sherman & Co., Port Henry, N. Y. Stock of Olds & Whipple, Hartford. Guaranteed 14 per cent. phosphoric acid. Cost $18.00 per ton.

It contained 14.97 per cent. phosphoric acid, chiefly in insoluble forms.

III. RAW MATERIALS OF HIGH GRADE CONTAINING POTASH.

MURIATE OF POTASH.

Six samples were examined as follows:

9716. Stock of Brainard Nursery & Seed Co., Thompsonville. It contained 51.30 per cent. potash.

10638. Stock of E. E. Burwell, New Haven. It contained 50.92 per cent. potash.

9698. Stock of Geo. E. Butler, Meriden. It contained 53.84 per cent. potash.

10581. Stock of M. Keeney, Somersville. It contained 53.40 per cent. potash.

11014. Stock of E. J. Leonard, Wallingford. It contained 48.08 per cent. potash.

10848. Stock of John Wm. Norton, Madison. It contained 62.76 per cent. potash.

SULPHATE OF POTASH.

10580. Stock of M. Keeney, Somersville. It contained 47.76 per cent. potash. Sold for $225.00 per ton. **Cost of potash 23.6 cents per pound.**

KAINIT.

10663. Sent by B. W. Ellis, County Agent, Putnam. It contained 15.50 per cent. potash.

The above samples, with exception of **10580,** represent small lots, in farmers' hands, probably not offered for sale.

COTTON HULL ASHES.

Five samples were analyzed as follows:

9756, 11364, 11365. Sold by Olds & Whipple, Hartford. Stock of J. B. Stewart, Windsor. Cost $6.00 per unit of water-soluble potash, equivalent to 30 cents per pound for actual potash. The samples contained 25.74, 19.62 and 18.70 per cent. of potash respectively.

11295. Sold by Olds & Whipple, Hartford. Stock of E. P. Brewer, Silver Lane. Cost $6.00 per unit of water-soluble potash, equivalent to 30 cents per pound for actual potash. It contained 24.66 per cent. of potash.

11448. Sold by Olds & Whipple, Hartford. Stock of John Wolf, Windsor. Cost $6.50 per unit of water-soluble potash, equivalent to 33 cents per pound for actual potash. It contained 19.29 per cent. of potash.

The cost of water-soluble potash in this form has ranged from 30 to 33 cents per pound and even higher.

10660. Stated to be "feldspar potash," but not from any stock offered for sale. It contained 48.44 per cent. of water-soluble potash, chiefly in form of muriate.

11055. Alpha Potash—Lime Fertilizer. Made by the Alpha Portland Cement Co., Easton, Pa. Sampled and sent by the manufacturer. It contained 2.59 per cent. of water-soluble potash, 27.32 per cent. of lime and 1.01 per cent. of magnesia.

It is quoted by the manufacturer at $12.00 per ton in bulk or $15.00 in bags. At the latter price and making no allowance for lime, potash would cost **at the works** 28.9 cents per pound.

The Potash Situation.

Already truck crops in this country have undoubtedly suffered from lack of potash as respects their yield and shipping quality. No marked reduction of our staple crops, which have a longer growth period, or of fruit crops, has come to our notice.

That this lack of potash will continue in 1919 is beyond question.

Before the war the country imported about 230,000 tons of actual potash, more than 90 per cent. of which was used as a fertilizer. Our annual requirements for the immediate future are estimated at 250,000 tons.

In 1917 the total domestic production was estimated at 32,573 tons from the following sources:

From the brines of western "lakes"	20,652 tons
kelp on the Pacific coast	3,572
molasses residues	2,846
the mineral alunite	2,402
all other sources	3,101
	32,573

The sources most promising for the future seem to be the brines and the dust from blast furnaces and cement kilns.

The data here given are taken from a publication of the U. S. Bureau of Mines, The Potash Situation, by A. W. Stockett.

In view of this critical situation, attention should be given to the careful conservation of the very considerable but neglected sources of home production. These have been discussed in Bulletin 198 of this Station, which is still available for distribution.

Some of the potash salts hitherto obtained from brines have contained considerable amounts of boric acid, and such salts have seriously damaged crops to which they were applied, as has been shown by Conner, of Purdue University, and others.

IV. RAW-MATERIALS CHIEFLY VALUABLE FOR NITROGEN AND PHOSPHORIC ACID.

FISH MANURES.

Nine samples of fish manures have been examined. "Dry fish scrap" as put on the market before the war contained quite uniformly about 8.25 per cent. of nitrogen and 6.0 per cent. of phosphoric acid. The analyses here given show from 7.8 to 9.71 per cent. of nitrogen, while phosphoric acid ranges from 3.13 to 14.32 per cent. Obviously they are not wholly dried fish scrap, as the term was formerly used, and four of them are decidedly inferior to it in composition and value. These last may contain fish residues with or without some foreign material. Not more than three have a fairly consistent composition for dried fish scrap.

No. **11296**, sent by Spencer Bros., Suffield, was damp and sticky, unfit mechanically to use in a drill. We understand that evaporated "soup" from the tankage manufacture is sometimes used in fertilizer mixtures and is apt to give this sticky consistence. For analyses see pages 134 and 135.

SLAUGHTER HOUSE TANKAGE.

Of the eight samples described in the table **10892** and **10889** have the composition of ground bone rather than of tankage. The same is true of **10601** although it was stated by the sender that it was sold for "blood tankage." **10891**, sold by the Nitrate Agencies Co., failed to meet its guaranty in nitrogen and greatly overran that of phosphoric acid. It is probable that the stock which it represented was wrongly branded or mixed with other goods. For analyses see pages 134 and 135.

MIXED BONE AND TANKAGE.

11099. Lister's Celebrated Ground Bone and Tankage acidulated, made by Lister's Agricultural Chemical Works, Newark, N. J. From stock of H. J. Stanclift, New Hartford. Cost $38.00 per ton.

Percentage composition

Nitrogen as nitrates	0.11
as ammonia	0.23
organic	2.77
total	3.11
Phosphoric acid—water-soluble	4.97
citrate-soluble	3.92
citrate-insoluble	3.34
total	12.23

ANALYSES OF

Station No.*	Manufacturer.	Dealer or Purchaser.
	Sampled by Station:	
10895	Apothecaries Hall Co	W. J. Reeves, Windsorville
11102	Berkshire Fertilizer Co	Joseph Zawistovski, Hazardville
10964	A. L. Koster	Spencer Bros, Suffield
11090	Olds & Whipple	Factory
10752	Va.-Car. Chemical Co	S. J. Stevens, Glastonbury
	Sampled by Purchaser.	
11087		Amer. Sumatra Co., Windsor Locl
10687	Standard Guano Co	A. L. Koster, Suffield
11296	A. L. Koster, Suffield	Spencer Bros., Suffield
10913		Orr Bros. Tobacco Co., Windsor

* 0.25 per cent. nitrogen in nitrates.

GARBAGE TANKAGE.

10605 is tankage prepared from city garbage. Sent by the Bridgeport Hydraulic Co., Bridgeport. It contained 1.87 per cent. of nitrogen and 2.17 per cent. of phosphoric acid. 85 per cent. of the material was in particles coarser than 1–50 inch.

ANALYSES OF

Station No.	Manufacturer.	Dealer or Purchaser.
10892	Apothecaries Hall Co	Chas. Templeton, Waterbury
10889	Conn. Fat Rend. & Fert. Corp	Factory
11179	Unknown	Apothecaries Hall Co., Waterbury
10618	N. Y. Dressed Meat Co	S. D. Woodruff & Sons, Orange
10891	Nitrate Agencies Co	A. G. Ross, Bridgeport
10601	Quality Seed Store (dealer)	Rowayton Green Houses, Rowayt
10602	Swift & Co	Rowayton Green Houses, Rowayt
10603	Godfrey Co-op. Fert. & Chem. Co.	Rowayton Green Houses, Rowayt

FISH MANURES.

Nitrogen.				Phosphoric Acid.			Total Phosphoric Acid.		
As Ammonia.	As Organic.	Total found.	Total guaranteed.	Water-soluble.	Citrate-soluble.	Citrate-insoluble.	Found.	Guaranteed.	Cost per ton.
0.16	8.15	8.31	8.20	0.59	9.24	4.49	14.32	12.06	$90.00
0.14	7.92	8.06	8.23	0.32	4.42	1.94	6.68	6.00	.....
0.46	8.71	9.42*	8.23	0.10	2.38	0.65	3.13	3.00	$95.00
0.09	9.62	9.71	8.23	0.35	4.74	2.48	7.57	5.5	100.00
0.10	9.18	9.28	8.20	0.43	5.63	1.79	7.85	5.0	....
....	....	7.82	8.22	....	....	....	....	....	....
0.37	8.94	9.31	8.22	0.18	2.51	0.83	3.52	3.0	....
....	....	8.61	8.30	....	....	....	2.75	....	....
0.06	7.88	7.94	....	0.38	4.43	0.31	5.12	....	82.00

BONE MANURES.

Twenty analyses of this material are tabulated on page 136. Only one fails to meet its guaranty, No. **11161,** Armour's Bone Meal, which contains 0.32 per cent. less nitrogen than guaranteed.

Five samples have a composition like that of untreated raw bone meal. The others represent bone variously treated, with the re-

SLAUGHTER HOUSE TANKAGE.

Nitrogen.				Phosphoric Acid.		Mechanical Analysis.		
As Ammonia.	As Organic.	Total found.	Total guaranteed.	Found.	Guaranteed.	Finer than 1-50 inch.	Coarser than 1-50 inch.	Cost per ton.
0.05	3.40	3.45	3.29	23.14	18.30	45.0	55.0	$50.00
0.06	3.08	3.14	3.29	23.44	20.00	58.0	42.0	50.00
0.13	5.50	5.63	....	20.00	....	....	....	....
....	....	7.96	8.22	....	....	....	....	....
0.08	5.95	6.03	8.22	11.26	4.57	25.0	75.0	80.00
0.14	1.95	2.09	....	18.59	....	60.0	40.0	....
0.34	6.16	6.50	....	9.10	....	46.0	54.0	....
0.16	4.50	4.66	....	7.54	....	44.0	56.0	....

V. MIXED FERTILIZERS.

NITROGENOUS SUPERPHOSPHATES.

The following tables include analyses of 263 samples taken by the Station Agent and 4 taken by others. Of those sampled by the Station Agent 109 were guaranteed to contain potash.

Regarding Guaranties.

Of the brands containing potash 29 failed in one or more respects to meet their guaranties. Of the 154 brands which did not contain potash, 34 failed to meet the guaranty either in nitrogen or in "available" phosphoric acid. Of all the nitrogenous superphosphates examined about 24 per cent. did not meet their guaranties in all particulars.

In most cases a deficiency in one ingredient was made up in money value by an overrun in the others.

In the following cases, however, this deficiency was not made good. Reckoning nitrogen and potash each at 30 cents per pound and "available" phosphoric acid at 6 cents, the deficiencies in money value of more than one dollar per ton were:

10734	Atlantic Packing Co.'s 4-8-2	$2.75
10732	Bowker's Complete	4.66
11079	Chittenden's Complete Tobacco and Onion Grower	2.56
11124	" Conn. Tobacco Grower	2.50
10755	Mapes Potato Manure	1.04
10796	A. A. C. Co.'s Ammoniated Fertilizer AAAA	2.04
10963	Frisbie's Tobacco Special	2.08
10960	International Ag'l Corp'n's. Buffalo N. E. Special	1.86
11105	Lister's Ag'l. Chem. Works' Atlas Brand	1.24
10836	N. E. Fertilizer Co.'s Potato Fertilizer	1.80
11132	Royster Guano Co.'s Overland Top Dresser	6.45
10791	" " " Perfecto Tobacco Formula	1.38

Regarding the Quality of Plant Food in Nitrogenous Superphosphates.

The potash given in the analyses is all soluble in water and readily available to crops.

The same is true of the "soluble" phosphoric acid. The "citrate-soluble" phosphoric acid, which with the water-soluble is called "available" in trade usage, is doubtless more readily available to crops than the citrate-insoluble, but there are probably considerable differences in the agricultural value of citrate-soluble phosphoric acid coming from different sources or materials. The same is true

of insoluble phosphoric acid. Thus, the insoluble phosphoric acid of bone is more quickly available to crops than that of phosphate rock or apatite.

Considering phosphoric acid alone, it is safest to buy those mixed fertilizers in which the proportion of insoluble phosphoric acid is smallest.

Regarding the nitrogen in mixed fertilizers, the availability of the portion which is in the form of nitrate or ammonia is well understood.

The organic nitrogen of mixed fertilizers comes from a great number of materials differing widely in their availability. A method of measuring approximately their availability to crops by their solubility in chemical reagents, has been devised and its value has been checked by vegetation tests.

The method has been sufficiently discussed in previous reports. Only its application to the tabulated analyses need be noticed here.

The organic nitrogen is separated into the water-soluble and water-insoluble. The water-soluble may be considered available.

The water-insoluble nitrogen is tested for solubility in a definitely prepared potassium permanganate solution. If less than 50 per cent. is soluble by the alkaline treatment and less than 80 per cent. by the neutral treatment, the water-insoluble organic nitrogen is considered inferior in quality. In the following table are given those analyses in which the water-insoluble nitrogen was judged inferior by both of the methods and in which, deducting the insoluble, inactive nitrogen from the nitrogen found, that remaining did not meet the nitrogen guaranty.

Analyses Requiring Special Notice.

10732. Bowker's Complete. The manufacturer's chemist found 2.75 per cent. of potash, whereas our report shows 2.36 per cent.

11025. Apothecaries Hall Co.'s Victor Tobacco Special with Cotton Seed Meal Base. As this sample failed to meet the guaranty, a second sample, **11175,** was drawn at the manufacturer's request, which fully met the guaranty.

10775. Berkshire Fertilizer Co.'s Root Fertilizer. The manufacturer advises that the goods should show between 3 and 4 per cent. of water-soluble phosphoric acid, instead of only 1.12 as is reported in the table.

Brands in Which Inferior Forms of Nitrogen are Indicated.

Station No.	Brand.	Organic Nitrogen.					
		Total	Water-soluble.	Active-*insoluble.*	Inactive-insoluble.	Per cent. active insoluble by Alkaline Method.	Per cent. active insoluble by Neutral Method.
11022	Apothecaries Hall Co.'s Victor Top Dresser	1.06	0.32	0.35	0.39	47.2	77.6
10774	Armour's 1-8-2	0.41	0.02	0.15	0.24	39.2	39.8
11021	" Wheat, Corn and Oat Special	0.76	0.22	0.26	0.28	47.6	74.8
10820	Bowker's Farm and Garden Phosphate	0.89	0.25	0.31	0.33	48.6	77.4
10799	Brown's Vegetable and Potato Grower	1.44	0.64	0.37	0.43	46.0	72.6
10739	E. F. Coe's New Englander Special	0.73	0.30	0.20	0.23	45.6	65.4
10884	" Ammoniated Dissolved Phosphate	1.06	0.44	0.29	0.33	46.4	77.8
10877	Frisbie's Connecticut Special	0.84	0.32	0.20	0.32	39.4	79.0
10970	Lowell Fertilizer Co.'s Bone Fertilizer	0.92	0.40	0.22	0.30	43.0	59.0
10755	Mapes' Potato Manure	0.81	0.14	0.26	0.41	38.2	74.8
10825	New England Fertilizer Co.'s Corn and Grain Fertilizer	0.83	0.29	0.23	0.31	43.4	76.4
10769	" " " " Superphosphate	1.04	0.40	0.30	0.34	47.0	62.2
10761	Olds & Whipple's Potato and All Crop Fertilizer	0.87	0.17	0.25	0.45	36.4	68.0
10981	Parmenter & Polsey's Plymouth Rock Brand	1.24	0.47	0.36	0.41	47.2	76.2
10980	" " Star Brand Superphosphate	1.07	0.42	0.29	0.36	44.4	69.0
10762	Royster Guano Co.'s Corn and Oats Fertilizer	0.86	0.37	0.19	0.30	39.6	62.2
10993	" " " Dreadnought Fertilizer	0.75	0.28	0.20	0.27	42.2	56.8
11109	C. M. Shay's Shay's Formula	2.31	0.90	0.66	0.75	47.0	77.6

10876, International Agricultural Corporation's Buffalo Tobacco Grower contained less nitrogen and phosphoric acid than was guaranteed. Another sample was drawn at the manufacturer's request, **11133,** which met the guaranty.

10819, Royster Guano Co.'s Overland Top Dresser showed a considerable deficiency of nitrogen but nearly double the amount of phosphoric acid which was guaranteed. A second sample, **11132,** drawn from another lot at the manufacturer's request, contained less nitrogen than the former and less than half as much phosphoric acid. It is doubtful if either sample represents the average composition of this brand.

10791, Royster Guano Co.'s Perfecto Tobacco Manure, contained 0.3 per cent. less nitrogen than was guaranteed. A second sample, **11123,** drawn at the manufacturer's request from another lot, fully met the guaranty.

Regarding the Prices of Mixed Fertilizers.

The prices given in the table are those named by the dealer as cash retail ton prices.

The price of a given brand will be regulated, not only by its cost to the retailer, but also by his expenses for freight, storage and other overhead charges and by his margin of profit. This however does not, we believe, vitiate a comparison of average cost to the farmer for the purpose of this discussion.

There are a considerable number of brands which have the same guaranties and a like composition. Thus, we have 22 brands in each of which 3.29 per cent. of nitrogen and 10 per cent. of "available" phosphoric acid are guaranteed. There are 9 brands in which the same amount of nitrogen, a little less phosphoric acid, and 1 per cent. of potash are guaranteed.

The analyses of each of these different groups have been averaged with the prices, rejecting those in which the prices were very far from the average. As is justified by the figures previously given in this report, the phosphoric acid has been given a value of 8 cents and potash of 30 cents per pound, and with this allowance the cost of the nitrogen in the different groups has been calculated. The following table gives the results:

COST OF NITROGEN IN NITROGENOUS SUPERPHOSPHATES.

No. of Brands.	Per cent. of Nitrogen Guaranty.	Average percentage found of Nitrogen.	"Available" Phosphoric Acid.	Potash.	Nitrogen costs cents per pound.	Average cost per ton.
Superphosphates without potash.						
7	0.82	1.00	10.11	....	96.0	$35.37
18	1.65	1.82	10.48	....	60.9	38.86
15	2.47	2.54	10.00	....	56.8	44.86
22	3.29	3.39	10.49	....	50.3	50.85
15	4.11	4.13	8.62	....	51.9	56.23
11	4.11	4.19	4.50	....	64.0	60.83
Superphosphates with 1 per cent. potash.						
10	1.65	1.77	9.51	1.12	71.0	47.06
10	2.06	2.26	9.11	1.01	64.2	49.65
13	2.47	2.55	9.15	1.06	54.3	48.70
9	3.29	3.36	9.45	1.15	52.0	56.94
8	4.11	4.36	7.02	1.17	52.5	64.03

The table is worth careful study by prospective purchasers. It shows quite conclusively that the buyer of brands with only 0.82 per cent. of nitrogen in them has paid not quite double as much for nitrogen as he would pay if he had bought goods with a higher guaranty of nitrogen and at a higher price. He would get his nitrogen cheapest if he bought with a guaranty of at least 2.47 per cent. nitrogen.

The buyer would save money by paying $50.85 for a 3.29 nitrogen brand, instead of paying $15.00 a ton less for 0.82 per cent. nitrogen goods. It was better buying to pay $64 for a 5-7-1 formula than to pay $47 for a 2.5-10-1 formula.

The reason is quite simple. It costs as much labor and material to mix, bag, ship and sell a low-grade fertilizer as it does to prepare high-grade goods, and they are practically alike on every ton, whether of high or low grade; therefore, they make the cost of plant food higher in those goods in which the amount of plant food is relatively small.

For example, suppose a ton of fertilizer (A) contains 40 pounds (2 per cent.) of nitrogen, and another (B) contains 80 pounds (4 per cent.) of nitrogen, and both contain equal amounts of phosphoric acid and potash. The nitrogen in each costs the manufacturer 30 cents per pound, and let us assume that the other plant food cost $12. The "overhead charges" for costs and profits of manufacturer and sale will be alike in each case, which we will assume to be $12 also.

	A	B
Cost of nitrogen	$12.00	$24.00
Cost of phosphoric acid and potash	12.00	12.00
Overhead charges	12.00	12.00
Cost to farmer	$36.00	$48.00

In A, $24 worth of plant food costs $36. In B, $36 worth costs $48. Hence in A, $1 worth of plant food costs $\frac{36}{24}$, or $1.50, and in B $\frac{48}{36}$, or $1.33.

These "overhead charges" have never been so great as now. The Station has always advised the buying of high-grade goods, but at present it is imperative.

There is nothing in the argument that if one wants to use only a small amount of nitrogen (perhaps on oats, for example) he should buy a formula containing a small amount of nitrogen. Many farmers need to get away from the idea of putting on so many pounds (or bags!) of fertilizer to the acre, and to figure only on the number of pounds of fertilizer ingredients which their land or crops need.

TABLE I—NITROGENOUS SUPERPHOSPHATES

Station No.	Manufacturer and Brand.	Place of Sampl
	Sampled by Station:	
	American Agricultural Chemical Co., New York City.	
10801	Complete Manure for Top Dressing 1916	Thompsonville
10898	Lion Brand Potato Manure	Waterbury
11164	Potomac Complete Potato Manure 1916	Orange
10869	*Sure Growth Phosphate 1916*	*Guilford*
10902	Bradley's Complete Manure for Potatoes and Vegetables 1916	Bristol
11029	Bradley's Corn Phosphate 1916	Willimantic
11065	Bradley's Half Century Fertilizer 1916	Canaan
10900	Bradley's New Method Fertilizer 1916	Middletown
11030	Bradley's Potato Fertilizer 1916	Willimantic
10821	Bradley's Patent Superphosphate 1916	Bristol
10754	Bradley's Potato Manure 1916	Norwalk
10901	Bradley's Sea Fowl Guano 1916	Middletown
11103	Bradley's Tobacco Manure	East Hartford
10800	Bradley's Unicorn 1916	Glastonbury
10803	East India Corn King 1916	Burnside
10804	East India Potato and Garden Manure	Burnside
10904	Great Eastern General 1916	New Canaan
10809	Great Eastern Northern Corn Special 1916	East Hampton
10903	Great Eastern Potato Manure 1916	East Hampton
10810	Packers Union Gardeners' Complete Manure 1916	East Hampton
10867	Quinnipiac Ammoniated Dissolved Bone 1916	Branford
11122	Quinnipiac B. Fertilizer	Shelton
10740	Quinnipiac Climax Phosphate 1916	Milford
10906	Quinnipiac Fish and Potash Mixture 1916	Branford
10907	Quinnipiac Market Garden Manure 1916	Milford
10905	Quinnipiac Potato Phosphate 1916	South Norwalk
11163	Wheeler's Corn Fertilizer 1916	Riverton
11064	Wheeler's Cuban Tobacco Grower 1916	New Milford
10909	Williams and Clark's Americus Corn Phosphate 1916	South Manchestc
10822	Williams and Clark's Americus H. G. Special for Potatoes and Root Crops 1916	Waterbury
10773	Williams and Clark's Americus Potato Manure 1916	Waterbury
10908	Williams and Clark's Special Prolific Crop Producer	Waterbury
	Armour Fertilizer Works, Chrome, N. J.	
†10774	Armour's 1-8-2	Norwalk
10742	Armour's 2-8-3	New Haven
11101	Armour's Special Tobacco Grower No. 1	Hazardville
†11021	Armour's Wheat, Corn and Oats Special	New Haven
10738	Bidwell's 3-8-1	Windsor Locks
	Atlantic Packing Co., New Haven.	
*10734	Atlantic 4-8-2	New Haven

* See note on page 138. † See table on page 140.

WITH POTASH.

·ogen. Organic, water-insoluble.	·ogen. Total. Found.	·ogen. Total. Guaranteed.	Phosphoric Acid. Water-soluble.	Phosphoric Acid. Citrate-soluble.	Phosphoric Acid. Citrate-insoluble.	Phosphoric Acid. Total. Found.	Phosphoric Acid. Total. Guaranteed.	Phosphoric Acid. So-called "Available." Found.	Phosphoric Acid. So-called "Available." Guaranteed	
0.98	4.40	4.11	6.43	2.22	1.11	9.76	9.00	8.65	8.00	0
0.51	3.28	3.29	7.09	3.16	1.37	11.62	11.00	10.25	10.00	2
0.74	1.75	1.65	6.76	2.72	2.01	11.49	10.00	9.48	9.00	0
0.63	2.53	2.47	7.23	2.77	2.05	12.05	10.00	10.00	9.00	0
0.81	3.32	3.29	6.95	2.58	1.50	11.03	10.00	9.53	9.00	0
0.45	2.34	1.65	5.56	3.42	0.79	9.77	11.00	8.98	10.00	0
0.74	2.10	2.06	7.23	2.84	1.61	11.68	11.00	10.07	10.00	0
0.83	1.88	0.82	4.58	4.06	1.13	9.77	9.00	8.64	8.00	0
0.42	2.34	2.06	5.34	3.34	0.79	9.47	9.00	8.68	8.00	0
0.74	2.23	2.06	5.88	2.65	1.30	9.83	9.00	8.53	8.00	0
0.56	2.54	2.47	7.80	1.97	2.01	11.78	10.00	9.77	9.00	0
0.46	1.04	0.82	7.10	3.49	1.83	12.42	11.00	10.59	10.00	0
2.16	4.46	4.53	0.20	3.91	0.09	4.20	4.00	4.11	3.00	0
0.78	2.03	1.65	5.45	4.27	1.54	11.26	10.00	9.72	9.00	0
1.13	2.55	2.47	5.51	4.01	2.17	11.69	10.00	9.52	9.00	0
1.39	3.51	3.29	6.76	2.63	1.48	10.87	11.00	9.39	9.00	0
0.46	1.12	0.82	6.06	3.06	1.38	10.50	9.00	9.12	8.00	0
0.52	2.22	2.06	2.46	5.21	2.53	10.20	9.00	7.67	8.00	0.
0.67	2.12	2.06	7.91	2.09	1.85	11.85	11.00	10.00	10.00	0.
0.65	2.70	2.47	7.49	1.86	1.42	10.77	10.00	9.35	9.00	0.
0.67	1.87	1.65	7.58	2.88	0.91	11.37	10.00	10.46	9.00	0.
0.59	1.27	1.23	6.94	3.18	1.47	11.59	11.00	10.12	10.00	0
0.27	0.95	0.82	4.83	3.68	1.06	9.57	9.00	8.51	8.00	0
1.21	2.41	2.47	4.89	4.17	1.62	10.68	10.00	9.06	9.00	0
0.75	3.55	3.29	7.24	2.28	1.29	10.81	10.00	9.52	9.00	0.
0.46	2.16	2.06	3.13	4.66	2.24	10.03	9.00	7.79	8.00	0.
0.58	1.70	1.65	7.74	2.29	1.82	11.85	11.00	10.03	10.00	0.
3.38	4.63	4.53	0.83	2.59	0.70	4.12	4.00	3.42	3.00	0.
0.64	1.94	1.65	7.55	2.87	0.72	11.14	11.00	10.42	10.00	0.
0.90	3.48	3.29	7.33	1.81	0.90	10.04	10.00	9.14	9.00	0.
0.55	2.23	2.06	3.71	4.12	2.33	10.16	9.00	7.83	8.00	0.
0.22	0.95	0.82	4.41	4.10	1.20	9.71	9.00	8.51	8.00	0.
0.39	0.83	0.82	3.34	4.55	1.30	9.19	8.50	7.89	8.00	0.
1.41	1.64	1.65	4.64	3.30	0.91	8.85	8.50	7.94	8.00	1.
3.29	4.50	4.11	3.31	1.73	1.15	6.19	4.50	5.04	4.00	0.
0.54	0.97	0.82	4.05	2.93	0.68	7.66	7.50	6.98	7.00	0.
1.23	2.35	2.47	5.50	3.63	0.93	0.06	8.50	9.13	8.00	0.
0.74	3.23	3.29	4.26	4.15	1.82	10.23	9.00	8.41	8.00	1.

TABLE I—NITROGENOUS SUPERPHOSPHATES.

Station No.	Manufacturer and Brand.	Place of Sampli
	Sampled by Station:	
	Bowker Fertilizer Co., New York City.	
11057	Bowker's All Round Fertilizer 1916	Buckland
11070	Bowker's Ammoniated Food for Flowers	Waterbury
*10732	†Bowker's Complete	Milldale
11062	Bowker's Complete Alkaline Tobacco Grower 1916	West Suffield
‡10820	Bowker's Farm & Garden Phosphate 1916	Plainville
11061	Bowker's Hill & Drill Phosphate 1916	Manchester
11069	Bowker's Lawn and Garden Dressing 1918	New Haven
11037	Bowker's Potato Phosphate 1916	Rockville
11060	Bowker's Sure Crop Phosphate 1916	Manchester
11068	*Stockbridge Early Crop Manure 1916*	*Milldale*
11067	Stockbridge General Crop Manure 1916	Willimantic
	E. D. Chittenden Co., Bridgeport, Conn.	
11135	Complete Tobacco and Onion Grower, 1% Potash	Rockville
*11079	Complete Tobacco and Onion Grower, 2% Potash	Enfield
*11124	Connecticut Tobacco Grower, 2% Potash	Suffield
11134	Tobacco Special 2% Potash	Suffield
	Coe-Mortimer Co., New York City.	
11072	H. G. Potato Fertilizer Revised	Greenwich
‡10739	New Englander Special 1916	Milford
11078	Red Brand Excelsior Guano 1916	Glastonbury
	L. T. Frisbie Co., New Haven, Conn.	
10959	Frisbie's 4-8-4	Guilford
	International Agricultural Corporation, Buffalo, N. Y.	
10770	Buffalo Economy	Ansonia
10962	Buffalo General Favorite	West Suffield
10771	Buffalo Tip Top	Ansonia
11075	Buffalo Triumph	Litchfield
	Lister's Agricultural Chemical Works, Newark, N. J.	
10966	Corn and Potato Fertilizer 1916	West Suffield
11098	Potato and Corn No. 2 Fertilizer 1916	New Hartford
11088	Perfect Potato Manure 1916	Burnside
11076	Potato Manure 1916	Rockville
11131	Special Crop Producer 1916	Mt. Carmel
11097	Special Tobacco Fertilizer 1916	Brookfield
10965	Standard Pure Superphosphate of Lime 1916	West Suffield
	Lowell Fertilizer Co., Boston, Mass.	
11130	Lowell 2-8-4	Enfield

* See note on page 138. † See note on page 139. ‡ See table on

WITH POTASH—(*Continued*).

n.			Phosphoric Acid.							Potash.			
	Total.					Total.		So-called "Available."					
Water-insoluble.	Found.	Guaranteed.	Water-soluble.	Citrate-soluble.	Citrate-insoluble.	Found.	Guaranteed.	Found.	Guaranteed.	As Muriate.	Total.	Guaranteed.	Station No.
6	2.14	2.06	7.19	3.50	1.30	11.99	11.00	10.69	10.00	0.39	1.13	1.00	**11057**
	2.92	2.47	0.15	6.06	1.66	7.87	7.00	6.21	6.00	2.38	2.82	2.00	**11070**
6	3.06	3.29	7.59	2.88	1.07	11.54	11.00	10.47	10.00	0.68	2.36	3.00	**10732**
9	4.31	4.11	0.87	3.71	0.45	5.03	5.00	4.58	4.00	0.32	1.28	1.00	**11062**
4	1.37	1.65	7.11	2.61	1.37	11.09	11.00	9.72	10.00	0.64	1.31	1.00	**10820**
6	2.65	2.47	6.74	2.63	1.13	10.50	10.00	9.37	9.00	0.35	1.11	1.00	**11061**
1	2.56	2.47	3.53	4.33	2.09	9.95	9.00	7.86	8.00	0.28	0.88	1.00	**11069**
4	1.79	1.65	7.40	2.47	1.57	11.44	11.00	9.87	10.00	0.29	1.03	1.00	**11037**
8	1.06	0.82	7.46	3.04	1.83	12.33	11.00	10.50	10.00	0.51	1.08	1.00	**11060**
2	4.24	4.11	6.62	2.03	0.97	9.62	9.00	8.65	8.00	0.31	1.31	1.00	**11068**
1	3.52	3.29	5.54	3.90	1.02	10.46	10.00	9.44	9.00	0.47	1.01	1.00	**11067**
6	3.76	3.29	4.55	3.43	1.50	9.48	9.00	7.98	8.00	0.25	1.02	1.00	**11135**
8	3.09	3.29	6.30	1.97	0.38	8.65	9.00	8.27	8.00	0.51	1.72	2.00	**11079**
3	4.69	4.94	2.38	2.22	1.14	5.74	5.00	4.60	4.00	0.36	1.73	2.00	**11124**
1	4.31	4.12	1.82	2.60	0.79	5.21	5.00	4.42	4.00	0.65	2.26	2.00	**11134**
6	3.66	3.29	6.29	3.94	1.02	11.25	11.00	10.23	10.00	1.14	2.93	3.00	**11072**
3	0.78	0.82	6.59	2.57	1.25	10.41	9.00	9.16	8.00	0.31	0.85	1.00	**10739**
3	4.18	4.11	6.63	1.92	1.02	9.57	9.00	8.55	8.00	0.24	1.16	1.00	**11078**
0	3.57	3.29	2.28	5.87	2.53	10.68	.....	8.15	8.00	2.41	4.93	4.00	**10959**
7	1.69	1.60	7.09	3.61	1.30	12.00	11.00	10.70	10.00	0.86	0.86	1.00	**10770**
9	1.16	0.80	7.16	2.23	0.47	9.86	9.00	9.39	8.00	0.70	0.70	1.00	**10962**
5	1.09	0.80	5.72	2.99	0.99	9.70	9.00	8.71	8.00	2.21	2.21	2.00	**10771**
1	1.56	1.60	6.90	2.38	0.47	9.75	9.00	9.28	8.00	1.68	1.68	2.00	**11075**
4	2.12	2.06	6.31	2.41	1.22	9.94	9.00	8.72	8.00	0.73	0.96	1.00	**10966**
5	2.14	2.06	8.26	2.43	1.34	12.03	11.00	10.69	10.00	0.58	1.18	1.00	**11098**
2	3.45	3.29	6.57	2.97	1.47	11.01	10.00	9.54	9.00	0.58	0.85	1.00	**11088**
9	4.31	4.11	5.45	2.97	1.52	9.94	9.00	8.42	8.00	0.40	0.98	1.00	**11076**
1	0.85	0.82	5.73	2.85	1.09	9.67	9.00	8.58	8.00	0.64	1.06	1.00	**11131**
3	2.20	2.05	8.19	2.29	1.28	11.76	11.00	10.48	10.00	0.68	1.21	1.00	**11097**
4	2.66	2.47	8.28	1.75	0.81	10.84	10.00	10.03	9.00	0.74	1.15	1.00	**10965**
7	1.81	1.64	2.37	5.63	1.51	9.51	9.00	8.00	8.00	2.11	5.31	4.00	**11130**

TABLE I—NITROGENOUS SUPERPHOSPHATES.

Station No.	Manufacturer and Brand.	Place of Sampl
	Sampled by Station:	
	The Mapes Formula & Peruvian Guano Co., New York City.	
10767	Corn Manure 1916 Brand	Windsor Locks. .
10737	General Special 1916 Brand	Windsor Locks. .
*10755	†Potato Manure 1916 Brand	Windsor Locks. .
10973	Tobacco Manure 1916 Brand	Hartford
10756	Tobacco Starter Improved	Hartford
10972	Top Dresser Half Strength 1916 Brand	Southington
10736	Top Dresser Full Strength 1916 Brand	Suffield
	National Fertilizer Co., New York City.	
10823	Complete Root and Grain Fertilizer 1916	Silver Lane
11038	Eureka Potato Fertilizer 1916	South Manchest
11096	Extra High Grade Manure 1916	West Cheshire. .
10741	Potato Phosphate 1916	Wallingford
11036	Tobacco Special 1916	Simsbury
10976	Universal Phosphate 1916	Simsbury
10977	XXX Fish and Potash 1916	South Manchest
	Olds & Whipple, Hartford, Conn.	
10979	Complete Corn, Potato and Onion Fertilizer	Ellington
10978	Complete Tobacco Fertilizer	South Windsor. .
11137	Complete Tobacco Fertilizer	Chicopee Falls, M
11136	Complete Tobacco Fertilizer	Chicopee Falls, M
	Rogers & Hubbard Co., Portland, Conn.	
10720	Hubbard's Bone Base Soluble Potato Manure	Milford
10807	R and H. Tobacco Grower (Vegetable Formula)	Windsor
	F. S. Royster Guano Co., Baltimore, Md.	
11129	Arrow Head Tobacco Fertilizer	Bloomfield
†10993	Dreadnought Fertilizer	Watertown
11092	Drillwell Phosphate	Glastonbury
10733	Fish and Potash Mixture	Cheshire
10992	Logical Compound	Plainville
	Sanderson Fertilizer & Chemical Co., New Haven, Conn.	
10829	Atlantic Coast Bone, Fish & Potash 1916	East Hampton. .
10830	Corn Superphosphate 1916	Derby
10994	Formula A 1916	Shelton
10995	Formula B 1916	Glastonbury
10731	Potato Manure 1916	Plainville
11128	Special Formula A	Niantic
11127	Kelsey's Bone, Fish and Potash 1916	Branford

* See note on page 138. † See table on page 140.

WITH POTASH—(*Continued*).

Nitrogen.				Phosphoric Acid.							Potash.		
Organic, water-soluble.	Organic, water-insoluble.	Total.		Water-soluble.	Citrate-soluble.	Citrate-insoluble.	Total.		So-called "Available."		As Muriate	Total.	Guaranteed.
		Found.	Guaranteed.				Found.	Guaranteed.	Found.	Guaranteed.			
).11	0.52	2.67	2.47	3.32	5.00	2.67	10.99	10.00	8.32	8.00	0.23	0.57	1.00
).18	1.14	6.28	5.76	1.74	4.97	2.17	8.88	8.00	6.71	6.00	0.37	1.09	1.00
).14	0.67	3.69	3.71	2.58	6.05	2.14	10.77	8.00	8.63	8.00	0.21	0.72	1.00
).19	2.79	8.71	8.23	0.04	5.74	2.46	8.24	8.00	5.78	5.00	0.65	1.71	1.00
).14	1.17	4.39	4.12	1.00	5.29	3.34	9.63	8.00	6.29	6.00	0.25	0.85	1.00
0.29		5.69	4.94	0.55	2.11	1.34	4.00	4.00	2.66	2.50	0.47	0.78	0.50
...	0.21	10.25	9.88	0.63	5.56	1.46	7.65	8.00	6.19	5.00	0.96	2.54	1.00
).36	0.79	3.49	3.29	6.98	2.07	1.38	10.43	10.00	9.05	9.00	0.47	1.26	1.00
).26	0.55	2.83	2.47	6.86	2.28	1.07	10.21	10.00	9.14	9.00	0.39	1.09	1.00
).57	1.73	4.42	4.11	3.59	4.86	1.16	9.61	9.00	8.45	8.00	0.52	0.97	1.00
).51	0.48	2.17	2.06	2.98	4.49	2.32	9.79	9.00	7.47	8.00	0.31	0.86	1.00
).36	3.40	5.25	4.53	1.32	2.48	0.52	4.32	4.00	3.80	3.00	0.20	1.40	1.00
).07	0.45	0.87	0.82	7.34	2.68	1.80	11.82	11.00	10.02	10.00	0.48	1.07	1.00
).25	1.12	2.75	2.06	5.99	4.36	1.23	11.58	11.00	10.35	10.00	.0.29	0.90	1.00
).40	1.75	3.65	3.30	2.69	4.68	0.79	8.16	6.00	7.37	6.00	0.58	2.33	1.00
).47	3.10	4.50	4.11	0.57	3.75	0.17	4.49	3.00	4.32	3.00	0.67	4.27	4.00
...	....	4.61	4.11	....	.....	....	4.80	3.00	.....	.....	.....	4.20	3.00
).47	3.20	4.67	4.11	0.35	3.96	0.19	4.50	3.00	4.31	3.00	0.37	4.12	4.00
).78	1.06	4.63	4.25	2.34	7.13	3.83	13.30	13.00	9.47	10.00	0.26	1.29	1.00
).39	3.17	5.30	5.00	0.10	4.40	2.29	6.79	5.00	4.50	4.00	0.27	0.98	0.50
).55	2.28	3.86	4.11	2.22	2.08	0.50	4.80	4.50	4.30	4.00	0.33	2.22	2.00
).28	0.47	1.65	1.65	4.35	3.80	0.92	9.07	8.50	8.15	8.00	0.64	2.04	2.00
).24	0.82	2.39	2.47	4.79	3.82	1.16	9.77	8.50	8.61	8.00	0.47	1.37	1.00
).23	0.47	1.67	1.65	5.49	2.28	0.67	8.44	8.50	7.77	8.00	0.51	1.02	1.00
).25	0.48	1.65	1.65	5.31	2.68	0.75	8.74	8.50	7.99	8.00	0.54	0.96	1.00
).38	0.86	1.79	1.65	4.85	4.43	2.02	11.30	10.00	9.28	9.00	0.94	1.23	1.00
).11	0.74	1.75	1.65	7.62	2.85	1.06	11.53	11.00	10.47	10.00	0.66	1.24	1.00
).60	1.16	3.22	3.29	5.28	4.64	1.41	11.33	10.00	9.92	9.00	0.89	0.89	1.00
).11	1.09	3.37	3.29	7.01	4.08	1.93	13.02	10.00	11.09	8.00	0.27	0.94	1.00
).53	1.01	2.26	2.06	5.05	4.48	1.87	11.40	9.00	9.53	8.00	0.25	1.21	1.00
...	1.12	3.13	3.29	5.45	3.19	0.88	9.52	9.00	8.64	8.00	2.38	4.56	4.00
).03	0.75	2.59	2.47	5.96	3.66	0.56	10.18	10.00	9.62	9.00	0.40	1.12	1.00

TABLE I—NITROGENOUS SUPERPHOSPHATES.

Station No.	Manufacturer and Brand.	Place of Sampling.
	Sampled by Station:	
	Virginia-Carolina Chemical Co., New York City.	
10998	Indian Brand for Tobacco No. 1	Simsbury
11108	Indian Brand for Tobacco No. 2	Simsbury
10840	National Corn, Grain and Grass Top Dresser	Hartford
10753	Owl Brand Potato and Truck Fertilizer with 1% Potash	Glastonbury
10832	XXXX Fish and Potash Mixture	Glastonbury
	Wilcox Fertilizer Co., Mystic, Conn.	
11006	Fish and Potash	Meriden
11001	Potato, Onion and Vegetable Phosphate	Ellington
10838	Tobacco Special	Ellington
	Sampled by Purchaser:	
10681	Frisbie's 4-8-2	Branford—The A. E. Plant Sons' Co

WITH POTASH—(*Concluded*).

	Nitrogen.				Phosphoric Acid.							Potash.			
			Total.					Total.		So-called "Available."					
	Organic, water-soluble.	Organic, water-insoluble.	Found.	Guaranteed.	Water-soluble.	Citrate-soluble.	Citrate-insoluble.	Found.	Guaranteed.	Found.	Guaranteed.	As Muriate.	Total.	Guaranteed.	Station No.
0	0.20	1.72	4.12	4.12	1.71	2.12	0.79	4.62	5.00	3.83	4.00	0.43	2.04	2.00	109
1	0.03	1.79	4.05	4.12	1.54	2.26	1.45	5.25	5.00	3.80	4.00	0.21	1.24	1.00	111
8	0.21	0.57	3.37	....	6.52	1.74	0.86	9.12	9.00	8.26	8.00	0.37	1.30	1.00	108
6	0.21	0.48	1.65	1.65	5.19	3.27	1.62	10.08	9.00	8.46	8.00	0.32	0.98	1.00	107
7	0.15	0.38	2.20	1.65	5.17	2.78	1.32	9.27	9.00	7.95	8.00	0.37	1.24	1.00	108
3	0.08	0.99	2.38	2.46	7.80	1.38	0.67	9.85	9.00	9.18	8.00	1.32	1.32	1.00	110
1	0.21	1.00	3.45	3.30	8.04	2.64	3.10	13.78	11.00	10.68	10.00	1.12	1.12	1.00	110
3	0.09	3.18	4.52	4.12	1.65	2.90	4.02	8.57	6.00	4.55	4.00	1.06	1.69	1.00	108
4	0.90	0.75	3.36	3.28	3.53	4.87	2.03	10.43	9.00	8.40	8.00	1.66	2.46	2.00	106

TABLE I—NITROGENOUS SUPERPHOSPHATES.

Station No.	Manufacturer and Brand.	Place of Sampling.
	Sampled by Station:	
	Virginia-Carolina Chemical Co., New York City.	
10998	Indian Brand for Tobacco No. 1	Simsbury
11108	Indian Brand for Tobacco No. 2	Simsbury
10840	National Corn, Grain and Grass Top Dresser	Hartford
10753	Owl Brand Potato and Truck Fertilizer with 1% Potash	Glastonbury
10832	XXXX Fish and Potash Mixture	Glastonbury
	Wilcox Fertilizer Co., Mystic, Conn.	
11006	Fish and Potash	Meriden
11001	Potato, Onion and Vegetable Phosphate	Ellington
10838	Tobacco Special	Ellington
	Sampled by Purchaser:	
10681	Frisbie's 4-8-2	Branford—The A. E. Plant Sons' Co

WITH POTASH—(*Concluded*).

Nitrogen.				Phosphoric Acid.							Potash.			
Organic, water-soluble.	Organic, water-insoluble.	Total.		Water-soluble.	Citrate-soluble.	Citrate-insoluble.	Total.		So-called "Available."		As Muriate.	Total.	Guaranteed.	Station No.
		Found.	Guaranteed.				Found.	Guaranteed.	Found.	Guaranteed.				
0.20	1.72	4.12	4.12	1.71	2.12	0.79	4.62	5.00	3.83	4.00	0.43	2.04	2.00	10998
0.03	1.79	4.05	4.12	1.54	2.26	1.45	5.25	5.00	3.80	4.00	0.21	1.24	1.00	11108
0.21	0.57	3.37	....	6.52	1.74	0.86	9.12	9.00	8.26	8.00	0.37	1.30	1.00	10840
0.21	0.48	1.65	1.65	5.19	3.27	1.62	10.08	9.00	8.46	8.00	0.32	0.98	1.00	10753
0.15	0.38	2.20	1.65	5.17	2.78	1.32	9.27	9.00	7.95	8.00	0.37	1.24	1.00	10832
0.08	0.99	2.38	2.46	7.80	1.38	0.67	9.85	9.00	9.18	8.00	1.32	1.32	1.00	11006
0.21	1.00	3.45	3.30	8.04	2.64	3.10	13.78	11.00	10.68	10.00	1.12	1.12	1.00	11001
0.09	3.18	4.52	4.12	1.65	2.90	4.02	8.57	6.00	4.55	4.00	1.06	1.69	1.00	10838
0.90	0.75	3.36	3.28	3.53	4.87	2.03	10.43	9.00	8.40	8.00	1.66	2.46	2.00	10681

TABLE II—NITROGENOUS SUPERPHOSPHATES.

Station No.	Manufacturer and Brand.	Place of Sampling.
	Sampled by Station:	
	American Agricultural Chemical Co., New York City.	
10794	Ammoniated Fertilizer A	Plantsville $
10772	Ammoniated Fertilizer AA	Waterbury
10868	Ammoniated Fertilizer AAA	Branford
*10796	Ammoniated Fertilizer AAAA	Branford
11059	Cereal and Root Fertilizer	Putnam
11005	Complete Manure without Potash	Ellington
10862	Extra Quality Potato Manure	Ellington
11008	Odorless Grass and Lawn Top Dressing without Potash	Stafford Springs
11058	Special Vegetable Fertilizer	Putnam
11066	5–8 Fertilizer	Windsor Locks
11009	Bradley's Grain Fertilizer	South Coventry
10899	Bradley's Root Crop Manure	Talcottville
11010	Bradley's Special Corn Phosphate without Potash	Willimantic
11011	Bradley's Special Potato Fertilizer without Potash	Willimantic
11026	Bradley's Special Potato Manure without Potash	Ellington
10789	Bradley's Tobacco Manure without Potash	Suffield
10802	East India Tobacco Special without Potash	Burnside
11032	Quinnipiac Special Corn Manure without Potash	New London
11031	Quinnipiac Special Potato Phosphate without Potash	Stafford Springs
10790	Quinnipiac Wrapper Leaf Brand Tobacco Manure without Potash	Suffield
10805	Williams and Clark's Seed Leaf Tobacco Manure without Potash 1916	South Manchester
11028	Williams and Clark's Special Americus Corn Phosphate without Potash	Ellington
11027	Williams and Clark's Special Americus Potato Manure without Potash	Ellington
	Apothecaries Hall Co., Waterbury, Conn.	
11023	Victor Corn, Fruit and All Crops	Factory
10759	Victor Market Gardeners' Special	Cheshire
10912	Victor Potato and Vegetable Special	Factory
†11025	Victor Tobacco Special (C. S. M. Base)	Windsorville
11175	Victor Tobacco Special (C. S. M. Base)	Burnside
‡11022	Victor Top Dresser for Grass and Grain	Milldale
	Armour Fertilizer Works, Chrome, N. J.	
11024	Special Tobacco Grower No. 2	Hazardville
10828	2–10	Manchester
10865	4–10	Hazardville
	Atlantic Packing Co., New Haven.	
10873	Corn and Grain Fertilizer	New Haven
10872	Potato Phosphate	New Haven
10792	Special Vegetable	New Haven

* See note on page 138. † See note on page 139. ‡ See table on page 14

WITHOUT POTASH.

	Nitrogen: In Ammonia.	Nitrogen: Organic, water-soluble.	Nitrogen: Organic, water-insoluble.	Nitrogen: Total. Found.	Nitrogen: Total. Guaranteed.	Phosphoric Acid: Water-soluble.	Phosphoric Acid: Citrate-soluble.	Phosphoric Acid: Citrate-insoluble.	Phosphoric Acid: Total. Found.	Phosphoric Acid: Total. Guaranteed.	Phosphoric Acid: So-called "Available." Found.	Phosphoric Acid: So-called "Available." Guaranteed.	Station No.
..	0.09	0.44	0.36	0.89	0.82	5.78	4.53	1.20	11.51	11.00	10.31	10.00	107
16	0.22	0.66	0.52	1.86	1.65	6.14	4.33	2.17	12.64	11.00	10.47	10.00	107
35	0.58	0.28	0.70	2.41	2.47	8.12	2.94	0.84	11.90	11.00	11.06	10.00	108
36	0.62	0.21	0.68	2.87	3.29	7.30	3.10	1.09	11.49	11.00	10.40	10.00	107
10	0.64	0.15	0.66	2.55	2.47	5.57	4.38	1.41	11.36	11.00	9.95	10.00	110
02	0.05	0.13	3.34	4.54	4.53	1.04	3.63	0.24	4.91	4.00	4.67	3.00	110
00	1.42	0.21	0.68	4.21	4.11	6.74	3.48	1.43	11.65	11.00	10.22	10.00	108
06	1.30	0.26	0.70	4.22	4.10	6.59	3.35	1.32	11.26	11.00	9.94	10.00	110
52	0.79	0.19	0.87	3.37	3.29	6.05	3.92	1.54	11.51	11.00	9.97	10.00	110
15	1.12	0.49	1.24	4.30	4.11	5.93	2.32	1.24	9.49	9.00	8.25	8.00	110
12	0.10	0.08	0.22	0.82	0.82	5.18	4.89	0.88	10.95	11.00	10.07	10.00	110
34	0.88	0.21	0.59	3.32	3.29	6.69	3.34	1.00	11.03	11.00	10.03	10.00	108
38	0.52	0.05	0.54	1.79	1.65	6.33	4.88	1.20	12.41	11.00	11.21	10.00	110
73	0.44	0.03	0.57	1.77	1.65	5.35	5.10	1.32	11.77	11.00	10.45	10.00	110
20	0.43	0.19	0.61	2.43	2.47	5.53	4.51	1.54	11.58	11.00	10.04	10.00	110
13	0.02	0.17	3.26	4.58	4.53	0.63	3.67	0.64	4.94	4.00	4.30	3.00	107
04	0.08	0.23	3.26	4.61	4.53	0.85	3.25	0.42	4.52	4.00	4.10	3.00	108
37	0.47	0.40	0.53	2.07	1.65	4.43	5.51	1.66	11.60	11.00	9.94	10.00	110
33	0.23	0.40	0.44	1.90	1.65	5.54	4.89	1.16	11.59	11.00	10.43	10.00	110
15	0.03	0.10	3.40	4.68	4.53	0.72	3.44	0.68	4.84	4.00	4.36	3.00	107
08	0.10	0.69	3.06	4.83	4.53	0.57	3.21	0.45	4.23	4.00	3.78	3.00	108
58	0.47	0.23	0.49	1.87	1.65	5.18	4.83	1.18	11.19	11.00	10.01	10.00	110
74	0.40	0.23	0.48	1.85	1.65	5.28	4.72	1.22	11.22	11.00	10.00	10.00	110
29	0.31	0.11	0.42	2.13	1.65	7.66	3.05	0.68	11.39	11.00	10.71	10.00	110
00	0.52	0.15	0.73	3.40	3.29	8.57	2.06	0.49	11.12	11.00	10.63	10.00	107
..	2.15	0.19	0.66	3.00	2.47	7.21	3.29	1.06	11.56	11.00	10.50	10.00	109
22	1.85	0.23	1.65	3.95	4.12	3.14	1.48	0.41	5.03	5.00	4.62	4.00	110
14	1.79	0.11	2.25	4.29	4.12	2.02	2.02	1.41	5.45	5.00	4.04	4.00	111
57	0.40	0.32	0.74	5.03	4.94	6.61	1.65	0.36	8.62	9.00	8.26	8.00	110
79	0.06	0.15	3.10	4.10	4.11	3.77	1.32	1.43	6.52	4.50	5.09	4.00	110
..	0.39	0.20	1.11	1.70	1.65	7.96	2.73	1.25	11.94	10.50	10.69	10.00	108
39	0.16	0.65	1.06	3.76	3.29	8.36	2.77	1.41	12.54	10.50	11.13	10.00	108
06	0.03	0.29	0.58	1.86	1.64	6.77	3.64	0.73	11.14	11.00	10.41	10.00	108
18	0.59	0.60	0.71	2.38	2.46	6.36	4.24	1.02	11.62	11.00	10.60	10.00	108
19	0.27	1.02	1.05	3.53	3.29	6.35	4.63	2.61	13.59	11.00	10.98	10.00	107

TABLE II—NITROGENOUS SUPERPHOSPHATES.

Station No.	Manufacturer and Brand.	Place of Sampling.
	Sampled by Station:	
	Atlantic Packing Co., New Haven. (*Continued*).	
10911	Tobacco Special	South Windsor
10910	Top Dresser for Grass and Market Garden	New Haven
	Berkshire Fertilizer Co., Bridgeport, Conn.	
11042	Ammoniated Bone Phosphate	Waterbury
11041	Grass Special	Jewett City
11043	Market Garden Fertilizer	Chester
11040	Potato and Vegetable Phosphate	Westport
*10775	Root Fertilizer	Wethersfield
10863	Tobacco Grower	Rockville
11063	Tobacco Starter	Suffield
	F. E. Boardman, Middletown, Conn.	
11056	Fertilizer for Tobacco and General Crops	Factory
	Bowker Fertilizer Co., New York City.	
11044	Four Ten Hill and Drill	Norwich
10795	High Nitrogen Mixture without Potash	Bristol
11034	One Ten Sure Crop	Willimantic
10834	Stockbridge Five Eight General Crop	Rockville
10717	Superphosphate with Ammonia 2%	New Haven
10758	Superphosphate with Ammonia 3%	Westport
10793	Superphosphate with Ammonia 4%	Milldale
11104	Superphosphate with Ammonia 5%	Plainville
11035	Three Ten All Round	Willimantic
10882	Tobacco Grower 1916	Thompsonville
10879	Two Ten Farm and Garden	Rockville
	F. O. Brown, Leonards Bridge, Conn.	
†10799	Vegetable and Potato Grower	Guilford
	E. D. Chittenden Co., Bridgeport, Conn.	
11125	Grass and Grain without Potash	Suffield
10878	Potato Special without Potash	Broad Brook
11106	Tobacco Special without Potash	Ellington
10757	Vegetable and Onion Grower without Potash	Greens Farms
	E. B. Clark Seed Co., Milford, Conn.	
10653	General Use Phosphate	Factory
10652	High Grade Special Fertilizer	Factory
10658	High Grade Special Fertilizer	Orange
	The Coe-Mortimer Co., New York City.	
10958	Connecticut Wrapper Grower without Potash	Poquonnock
10883	Excelsior Potato Fertilizer 1916	Greenwich

* See Note on page 139. † See table on page 140.

WITHOUT POTASH—(*Continued*).

Nitrogen.					Phosphoric Acid.							
			Total.					Total.		So-called "Available."		
In Ammonia.	Organic, water-soluble.	Organic, water-insoluble.	Found.	Guaranteed.	Water-soluble.	Citrate-soluble.	Citrate-insoluble.	Found.	Guaranteed.	Found.	Guaranteed.	Station No.
0.03	0.86	1.32	4.16	4.10	2.77	4.27	1.02	8.06	7.00	7.04	6.00	**10911**
1.76	0.64	0.75	3.89	4.10	5.45	3.08	0.63	9.16	9.00	8.53	8.00	**10910**
.....	0.06	0.73	1.27	0.80	3.58	6.87	0.51	10.96	11.00	10.45	10.00	**11042**
.....	0.17	1.39	5.06	5.00	0.65	4.77	0.35	5.77	6.00	5.42	5.00	**11041**
0.01	0.10	2.14	3.70	3.30	1.64	5.82	0.75	8.21	9.00	7.46	8.00	**11043**
0.01	0.13	1.21	2.35	1.70	3.36	6.27	0.83	10.46	11.00	9.63	10.00	**11040**
0.06	0.03	1.50	2.76	2.50	1.12	6.46	1.46	9.04	9.00	7.58	8.00	**10775**
0.04	0.64	2.53	4.51	4.11	1.37	2.62	0.41	4.40	4.00	3.99	3.00	**10863**
0.02	0.30	2.23	5.30	5.00	1.46	2.02	1.73	5.21	5.00	3.48	4.00	**11063**
0.09	0.59	1.50	3.54	3.29	2.03	5.39	0.97	8.39	......	7.42	7.00	**11056**
1.12	0.50	0.44	3.40	3.29	5.87	4.32	0.74	10.93	11.00	10.19	10.00	**11044**
3.13	0.30	1.04	8.29	8.23	4.61	1.07	0.72	6.40	6.00	5.68	5.00	**10795**
0.12	0.17	0.26	1.01	0.82	6.11	3.56	0.95	10.62	11.00	9.67	10.00	**11034**
1.28	0.35	0.83	4.06	4.11	6.92	1.91	1.97	10.80	9.00	8.83	8.00	**10834**
0.27	0.29	0.55	1.74	1.65	6.91	3.72	1.84	12.47	11.00	10.63	10.00	**10717**
0.39	0.38	0.57	2.48	2.47	6.90	2.98	2.47	12.35	11.00	9.88	10.00	**10758**
0.38	1.36	0.71	4.11	3.29	7.53	2.94	1.94	12.41	11.00	10.47	10.00	**10793**
1.15	0.46	1.14	4.34	4.11	5.81	2.48	1.28	9.57	9.00	8.29	8.00	**11104**
0.76	0.24	0.35	2.53	2.47	6.91	3.11	1.11	11.13	11.00	10.02	10.00	**11035**
0.07	0.40	2.88	4.32	4.11	0.94	3.58	0.61	5.13	5.00	4.52	4.00	**10882**
0.23	0.32	0.58	1.78	1.65	7.65	3.28	1.57	12.50	11.00	10.93	10.00	**10879**
0.42	0.64	0.82	3.08	2.87	8.30	2.60	0.63	11.53	11.00	10.90	10.00	**10799**
3.73	0.03	0.59	4.49	4.12	7.97	1.62	0.36	9.95	11.00	9.59	10.00	**11125**
0.63	0.14	0.21	3.31	3.29	5.95	5.06	0.96	11.97	11.00	11.01	10.00	**10878**
2.62	0.02	1.71	4.55	4.52	0.99	2.07	0.78	3.84	4.00	3.06	3.00	**11106**
1.63	0.23	0.41	2.27	2.47	8.77	2.29	0.27	11.33	11.00	11.06	10.00	**10757**
0.65	0.46		2.63	2.47	5.46	4.73	1.18	11.37	11.00	10.19	10.00	**10653**
.....	0.34	1.35	3.30	3.29	9.68	1.33	0.24	11.25	11.00	11.01	10.00	**10652**
.....	.....	.....	3.21	3.29	.....	.....	.....	11.69	11.00	......	......	**10658**
0.05	0.19	3.26	4.55	4.53	0.78	2.95	0.40	4.13	4.00	3.73	3.00	**10958**
1.34	0.09	1.11	4.52	4.11	8.71	1.77	0.96	11.44	11.00	10.48	10.00	**10883**

TABLE II—NITROGENOUS SUPERPHOSPHATES.

Station No.	Manufacturer and Brand.	Place of Sampling.
	Sampled by Station:	
	The Coe-Mortimer Co., New York City. (*Con.*)	
10797	H. G. Ammoniated Superphosphate 1916	Greenwich
*10884	Original Ammoniated Dissolved Phosphate 1916	Middletown
10788	Prolific Crop Producer 1916	Milford
11077	Tobacco Special	Simsbury
10787	Top Dressing Manure 1916	Milford
	Essex Fertilizer Co., Boston, Mass.	
10768	Fish Fertilizer	South Manchester
10881	Grain, Grass and Potato Fertilizer	South Manchester
10880	Market Garden and Potato Manure	North Haven
10835	Potato Phosphate	Ellington
11071	Tobacco 5–4	Rockville
	The L. T. Frisbie Co., New Haven, Conn.	
*10877	Connecticut Special	Meriden
10711	Corn and Grain Fertilizer	Meriden
10716	Market Garden and Top Dressing	New Haven
10885	Potato and Vegetable Grower	Cheshire
†10963	Tobacco Special	Hartford
	International Agricultural Corporation, Buffalo, N. Y.	
10875	Buffalo Farmers' Choice	West Suffield
11074	Buffalo Garden Truck	New Milford
†10960	Buffalo New England Special	Ansonia
10961	Buffalo Onion, Vegetable and Potato	Granby
11133	Buffalo Tobacco Grower	Warehouse Point
‡10876	Buffalo Tobacco Grower	West Suffield
	Lister's Agricultural Chemical Works, Newark, N. J.	
†11105	Atlas Brand	Rockville
10824	Celebrated Tobacco Fertilizer without Potash	Warehouse Point
10874	Complete Tobacco Fertilizer without Potash	Rockville
11073	Plant Food 1916	Danbury
11033	Superior Ammoniated Superphosphate 1916	Glastonbury
	Lowell Fertilizer Co., Boston, Mass.	
10714	Animal Brand	Wallingford
*10970	Bone Fertilizer	Rockville
10969	Empress Brand	Southington
10968	Potato Manure	Saybrook
10818	Potato Phosphate	Suffield
10967	Tobacco Grower	Rockville
	E. Manchester & Sons, Winsted, Conn.	
10971	Manchester's 1918 Formula	Ellington

* See table on page 140. † See note on page 138. ‡ See note on page

WITHOUT POTASH—(*Continued*).

Nitrogen.					Phosphoric Acid.							
			Total.					Total.		So-called "Available."		
In Ammonia.	Organic, water-soluble.	Organic, water-insoluble.	Found.	Guaranteed.	Water-soluble.	Citrate-soluble.	Citrate-insoluble.	Found.	Guaranteed.	Found.	Guaranteed.	Station No.
0.20	0.75	0.44	2.52	2.47	6.51	3.86	1.74	12.11	11.00	10.37	10.00	**10797**
0.08	0.44	0.67	1.72	1.65	6.31	3.75	2.02	12.08	11.00	10.06	10.00	**10884**
0.48	0.43	0.67	3.41	3.29	7.25	2.85	1.18	11.28	11.00	10.10	10.00	**10788**
0.06	0.11	3.17	4.54	4.11	3.26	1.58	0.42	5.26	5.00	4.84	4.00	**11077**
2.27	0.34	0.80	6.91	6.58	6.86	1.24	0.77	8.87	9.00	8.10	8.00	**10787**
0.03	0.45	0.61	2.35	2.46	6.96	3.02	0.68	10.66	11.00	9.98	10.00	**10768**
0.06	0.47	0.45	1.06	0.82	8.58	3.39	1.69	13.66	13.00	11.97	12.00	**10881**
0.37	0.53	0.83	3.04	2.87	7.90	2.61	0.61	11.12	11.00	10.51	10.00	**10880**
0.21	0.87	0.94	3.29	3.28	5.82	4.81	2.29	12.92	11.00	10.63	10.00	**10835**
0.15	0.95	1.50	4.37	4.10	0.92	4.93	1.25	7.10	5.00	5.85	4.00	**11071**
0.75	0.32	0.52	2.61	2.46	7.47	2.40	0.15	10.02	11.00	9.87	10.00	**10877**
0.28	0.08	0.51	1.80	1.64	6.50	3.46	0.58	10.54	11.00	9.96	10.00	**10711**
1.80	0.61	0.69	3.97	4.10	5.88	3.25	0.70	9.83	9.00	9.13	8.00	**10716**
0.30	1.05	0.99	3.61	3.28	5.68	4.60	2.58	12.86	11.00	10.28	10.00	**10885**
0.05	0.66	1.39	3.64	4.10	2.82	3.75	0.65	7.22	7.00	6.57	6.00	**10963**
0.23	.....	0.37	0.98	0.80	6.61	3.92	1.05	11.58	11.00	10.53	10.00	**10875**
0.90	0.43	0.99	3.36	3.30	6.24	4.50	1.46	12.20	11.00	10.74	10.00	**11074**
0.26	0.09	0.78	1.30	1.60	4.46	5.49	1.60	11.55	11.00	9.95	10.00	**10960**
0.41	0.18	1.08	2.82	2.50	7.15	3.49	0.92	11.56	11.00	10.64	10.00	**10961**
0.72	0.18	2.29	4.14	4.10	1.07	3.20	0.67	4.94	5.00	4.27	4.00	**11133**
0.98	0.08	1.48	3.94	4.10	1.31	2.78	0.78	4.87	5.00	4.09	4.00	**10876**
0.90	0.40	1.01	3.85	4.11	5.66	2.61	1.45	9.72	9.00	8.27	8.00	**11105**
0.05	0.07	2.89	4.41	4.53	2.28	1.30	0.55	4.13	4.00	3.58	3.00	**10824**
3.89	0.36	1.09	3.96	4.11	1.62	2.61	1.23	5.46	5.00	4.23	4.00	**10874**
0.15	0.27	0.37	0.96	0.82	6.85	3.62	0.97	11.44	11.00	10.47	10.00	**11073**
0.75	0.43	0.58	3.58	3.29	8.34	2.17	1.05	11.56	11.00	10.51	10.00	**11033**
0.59	0.49	0.67	2.71	2.87	6.49	4.27	0.47	11.23	11.00	10.76	10.00	**10714**
0.41	0.40	0.52	2.02	2.05	7.09	3.99	0.42	11.50	11.00	11.08	10.00	**10970**
0.42	0.54	0.52	1.57	1.23	7.60	3.03	0.40	11.03	11.00	10.63	10.00	**10969**
0.76	0.36	0.54	2.79	2.46	7.57	2.26	0.26	10.09	11.00	9.83	10.00	**10968**
0.29	0.96	1.04	3.57	3.28	5.77	5.25	1.96	12.98	11.00	11.02	10.00	**10818**
0.07	0.59	1.45	4.25	4.10	2.84	4.16	0.88	7.88	7.00	7.00	6.00	**10967**
0.15	0.91	1.04	2.50	2.47	5.40	4.73	1.20	11.33	......	10.13	10.00	**10971**

TABLE II—NITROGENOUS SUPERPHOSPHATES.

Station No.	Manufacturer and Brand.	Place of Sampling.
	Sampled by Station:	
	The Mapes Formula & Peruvian Guano Co., New York City.	
10826	5% Ammonia Special	Hartford
	National Fertilizer Co., New York City.	
10713	Nitrogen Phosphate Mixture No. 1	Wallingford
10712	Nitrogen Phosphate Mixture No. 2	Wallingford
10974	Nitrogen Phosphate Mixture No. 3	Suffield
10798	Nitrogen Phosphate Mixture No. 4	Guilford
11100	Nitrogen Phosphate Mixture No. 5	Somersville
10975	Tobacco Special without Potash	Warehouse Point
	New England Fertilizer Co., Boston, Mass.	
†10825	Corn and Grain Fertilizer	Madison
*10836	Potato Fertilizer	Rockville
11200	Special Tobacco Manure (5–4)	Suffield
†10769	Superphosphate	Suffield
	Olds & Whipple, Hartford, Conn.	
†10761	Potato and All Crop Fertilizer	New Britain
10764	Special Grass Fertilizer	Factory
11039	Special H. G. Tobacco Starter	Factory
10763	Special Onion, Corn and Potato Fertilizer	Factory
11174	Tobacco Special Fertilizer	East Hartford
10808	Tobacco Special Fertilizer	Windsor
	Parmenter & Polsey Fertilizer Co., Boston, Mass.	
11111	Grain Grower	Bloomfield
†10981	Plymouth Rock Brand	Highwood
†10980	Star Brand Superphosphate	Hartford
	The Rogers & Hubbard Co., Portland, Conn.	
10722	Hubbard's Bone Base Oats and Top Dressing	Milford
10721	Hubbard's Bone Base Soluble Corn and General Crops	Milford
10988	R. and H. All Round Phosphate	South Manchester
10989	R. and H. All Soils—All Crops Phosphate	Hamden
11094	R. and H. Bone Base Soluble Tobacco Manure	Gildersleeve
10990	R. and H. Climax Tobacco Brand	Windsor
10806	R. and H. Complete Phosphate	South Manchester
10827	R. and H. Potato Phosphate	South Manchester
	F. S. Royster Guano Co., Baltimore, Md.	
11095	Abundant Ammoniated Superphosphate	Watertown
10991	C. B. Fish Mixture	Cheshire
†10762	Corn and Oats Fertilizer	New Canaan
11089	Innovation Ammoniated Superphosphate	New Canaan
11093	Landmark Ammoniated Superphosphate	Madison

* See note on page 138. † See table on page 140.

WITHOUT POTASH—(*Continued*).

Nitrogen.					Phosphoric Acid.							
			Total.					Total.		So-called "Available."		
In Ammonia.	Organic, water-soluble.	Organic, water-insoluble.	Found.	Guaranteed.	Water-soluble.	Citrate-soluble.	Citrate-insoluble.	Found.	Guaranteed.	Found.	Guaranteed.	Station No.
0.03	0.03	1.09	4.25	4.12	3.23	5.40	2.83	11.46	10.00	8.63	8.00	**10826**
0.10	0.29	0.48	0.87	0.82	7.95	2.76	2.07	12.78	11.00	10.71	10.00	**10713**
0.21	0.50	0.58	1.87	1.65	4.93	4.42	2.32	11.67	11.00	9.35	10.00	**10712**
0.15	0.81	1.27	2.70	2.47	5.73	4.06	1.77	11.56	11.00	9.79	10.00	**10974**
0.98	0.61	1.07	3.41	3.29	7.25	3.03	1.50	11.78	11.00	10.28	10.00	**10798**
1.20	0.25	0.77	4.14	4.11	5.79	3.13	1.16	10.08	9.00	8.92	8.00	**11100**
0.06	0.72	3.18	4.58	4.53	0.71	2.86	0.49	4.06	4.00	3.57	3.00	**10975**
0.53	0.29	0.54	1.36	1.23	7.90	2.83	0.36	11.09	11.00	10.73	10.00	**10825**
0.37	0.21	0.50	2.09	2.46	6.74	3.61	0.51	10.86	11.00	10.35	10.00	**10836**
0.08	1.08	1.03	4.37	4.10	0.81	5.68	1.52	8.01	7.00	6.49	6.00	**11200**
0.49	0.40	0.64	2.88	2.87	7.99	2.23	0.59	10.81	11.00	10.22	10.00	**10769**
0.08	0.17	0.70	1.79	1.65	6.06	4.51	1.05	11.62	10.00	10.57	10.00	**10761**
0.13	0.14	2.20	5.11	4.95	3.79	1.71	0.59	6.09	4.00	5.50	4.00	**10764**
0.13	0.65	5.29	9.28	9.06	1.94	2.37	0.45	4.76	3.00	4.31	3.00	**11039**
0.09	0.23	1.08	2.60	2.45	6.02	3.43	0.68	10.13	8.00	9.45	8.00	**10763**
0.06	0.10	3.36	4.48	4.11	1.65	2.66	0.37	4.68	3.00	4.31	3.00	**11174**
0.05	0.17	3.30	4.43	4.11	1.55	1.85	0.35	3.75	3.00	3.40	3.00	**10808**
0.02	0.23	0.28	1.18	1.23	7.99	2.36	1.32	11.67	11.00	10.35	10.00	**11111**
0.58	0.47	0.77	2.91	2.87	7.02	3.70	0.55	11.27	11.00	10.72	10.00	**10981**
0.35	0.42	0.65	2.62	2.46	6.56	3.97	1.09	11.62	11.00	10.53	10.00	**10980**
0.13	0.67	0.66	6.34	6.00	0.05	5.02	6.83	11.90	12.00	5.07	6.00	**10722**
0.21	0.51	0.88	2.44	2.50	2.96	6.54	5.16	14.66	12.00	9.50	10.00	**10721**
0.02	0.15	0.28	1.82	1.62	3.87	2.68	1.75	8.30	7.50	6.55	7.00	**10988**
0.10	0.52	0.86	3.40	3.30	4.91	6.46	5.03	16.40	13.50	11.37	12.50	**10989**
0.16	1.09	1.31	5.05	5.00	2.04	8.50	4.59	15.13	13.00	10.54	10.00	**11094**
0.31	0.35	2.53	4.03	4.12	0.09	2.73	3.85	6.67	4.00	2.82	3.00	**10990**
0.09	0.07	0.37	1.29	1.00	3.94	3.48	1.93	9.35	8.00	7.42	7.50	**10806**
0.19	0.09	0.76	2.25	2.00	6.35	6.53	4.03	16.91	15.00	12.88	14.00	**10827**
1.94	0.16	1.75	4.02	4.11	8.12	2.05	0.82	10.99	10.50	10.17	10.00	**11095**
0.64	0.42	0.75	1.89	1.65	6.35	3.43	1.15	10.93	8.50	9.78	8.00	**10991**
0.10	0.37	0.49	0.96	0.82	3.39	4.40	1.46	9.25	8.50	7.79	8.00	**10762**
1.12	0.48	0.99	2.59	2.47	4.95	3.28	1.47	9.70	8.50	8.23	8.00	**11089**
2.04	0.21	1.49	3.85	3.29	8.35	1.84	0.75	10.94	10.50	10.19	10.00	**11093**

TABLE II—NITROGENOUS SUPERPHOSPHATES.

Station No.	Manufacturer and Brand.	Place of Sampling.
	Sampled by Station:	
	F. S. Royster Guano Co., Baltimore, Md. (*Cont.*)	
*11132	†Overland Top Dresser	Hazardville
†10819	Overland Top Dresser	Cheshire
11091	Penguin Ammoniated Superphosphate	Glastonbury
11123	Perfecto Tobacco Formula	New Milford
*10791	†Perfecto Tobacco Formula	Glastonbury
	Sanderson Fertilizer & Chemical Co., New Haven, Conn.	
11110	High Grade Ammoniated Phosphate	Westport
11138	High Grade Ammoniated Phosphate	East Hartford
10831	Phosphate without Potash	Shelton
10760	Special without Potash	Plainville
10996	Tobacco Grower 1916	Silver Lane
10719	Top Dressing for Grass and Grain without Potash 1916	Mt. Carmel
	The C. M. Shay Co., Groton, Conn.	
‡11109	Shay's Formula 4-8	Groton
	M. L. Shoemaker & Co., Philadelphia, Pa.	
10766	Swift-Sure Superphosphate for Tobacco and General Use	Windsor Locks
	Springfield Rendering Co., Springfield, Mass.	
10839	Animal Fertilizer	Thompsonville
	Virginia-Carolina Chemical Co., New York City.	
11000	Ammoniated Bone Phosphate for All Crops	Simsbury
10999	H. G. Corn and Vegetable Compound without Potash	North Haven
10765	Indian Brand for Tobacco without Potash	Glastonbury
11107	Tobacco and Onion Special	Glastonbury
	Wilcox Fertilizer Co., Mystic, Conn.	
10837	Corn Special	Ellington
11004	Grain Fertilizer	Ellington
11002	Grass Fertilizer	Ellington
	Worcester Rendering Co., Auburn, Mass.	
11007	Royal Worcester Potato and Vegetable Fertilizer	Norwich
	Sampled by Purchasers:	
10680	Frisbie's Market Garden and Top Dresser	*Branford:*—The A. E. Plant Sons' Co.
10679	Frisbie's Potato and Vegetable Grower	*Branford:*—The A. E. Plant Sons' Co.
10662	Olds & Whipple's Complete Tobacco Special	*West Suffield:*—H. C. Nelson

* See Note on page 138. † See note on page 141. ‡ See table on page 1

WITHOUT POTASH—(*Concluded*).

Nitrogen.					Phosphoric Acid.							
			Total.					Total.		So-called "Available."		
In Ammonia.	Organic, water-soluble.	Organic, water-insoluble.	Found.	Guaranteed.	Water-soluble.	Citrate-soluble.	Citrate-insoluble.	Found.	Guaranteed.	Found.	Guaranteed.	Station No.
2.24	0.29	1.42	4.00	4.94	2.90	1.42	0.59	4.91	5.50	4.32	5.00	**11132**
1.95	0.66	1.84	4.45	4.94	5.16	3.56	1.51	10.23	5.50	8.72	5.00	**10819**
1.00	0.26	0.54	1.86	1.65	6.81	3.25	1.07	11.13	10.50	10.06	10.00	**11091**
0.89	0.40	2.62	4.12	4.11	1.94	2.32	0.58	4.84	4.50	4.26	4.00	**11123**
0.93	0.24	2.51	3.81	4.11	2.26	2.10	0.55	4.91	4.50	4.36	4.00	**10791**
0.12	0.52	1.35	3.19	3.29	6.52	4.01	1.07	11.60	11.00	10.53	10.00	**11110**
0.81	.....	1.14	3.11	3.29	8.05	2.13	0.54	10.72	11.00	10.18	10.00	**11138**
0.10	0.58	0.58	1.73	1.65	4.54	5.47	1.61	11.62	11.00	10.01	10.00	**10831**
0.12	0.54	1.13	2.42	2.47	6.10	3.93	2.02	12.05	11.00	10.03	10.00	**10760**
0.05	0.17	3.01	4.27	4.53	0.98	2.96	0.51	4.45	4.00	3.94	3.00	**10996**
0.67	0.67	1.28	4.56	4.11	6.09	2.40	1.74	10.23	9.00	8.49	8.00	**10719**
0.06	0.90	1.41	3.22	3.29	6.01	3.85	1.27	11.13	11.00	9.86	10.00	**11109**
....	0.84	1.61	3.23	3.30	8.27	3.19	2.88	14.34	11.00	11.46	9.00	**10766**
0.04	0.81	0.46	2.43	2.46	7.76	4.13	1.07	12.96	11.00	11.89	10.00	**10839**
0.94	.....	0.24	1.47	1.65	8.16	3.33	0.20	11.69	11.00	11.49	10.00	**11000**
1.83	0.06	0.46	2.51	2.47	7.70	2.81	0.40	10.91	11.00	10.51	10.00	**10999**
1.89	0.29	1.51	3.78	4.12	4.31	0.85	0.38	5.54	5.00	5.16	4.00	**10765**
2.42	.....	0.62	3.38	3.29	5.42	2.68	1.34	9.44	9.00	8.10	8.00	**11107**
....	0.11	1.53	3.81	3.39	9.83	2.31	3.97	16.11	11.00	12.14	10.00	**10837**
0.02	0.05	0.94	1.83	1.65	8.79	2.73	0.24	11.76	11.00	11.52	10.00	**11004**
0.02	0.53	0.84	3.92	4.12	7.41	2.58	4.16	14.15	9.00	9.99	8.00	**11002**
0.42	0.66	1.14	2.70	3.29	7.35	4.89	3.30	15.54	11.00	12.24	10.00	**11007**
1.81	0.52	0.82	3.92	4.10	5.37	3.26	0.61	9.24	9.00	8.63	8.00	**10680**
0.22	1.06	0.97	3.47	3.29	6.02	4.39	2.32	12.73	11.00	10.41	10.00	**10679**
0.04	0.93	2.15	4.28	4.13	1.67	1.60	0.31	3.58	3.00	3.27	3.00	**10662**

VI. MISCELLANEOUS FERTILIZERS AND WASTE PRODUCTS.

SHEEP MANURE.

11126. Sheep Manure. Sold by Armour Fertilizer Works, Chrome, N. J. Stock of Chas. Templeton, Waterbury.

11217. Sheep Manure. Sold by Armour Fertilizer Works, Chrome, N. J. Stock of Quality Seed Store, Stamford.

10735. Magic Brand Ground Sheep Manure. Sold by Chicago Feed & Fertilizer Co., Chicago, Ill. Stock of F. S. Platt Co., New Haven.

11363. Sheep Manure. Sold by Mid-West Potash Co., Omaha, Neb. Sampled and sent by S. D. Woodruff & Sons, Orange.

10817. "Sheeps Head" Pulverized Sheep Manure. Sold by Natural Guano Co., Aurora, Ill. Stock of F. S. Bidwell & Co., Windsor Locks.

11278. Wizard Brand. Sold by F. S. Platt Co., New Haven. Sampled and sent by J. W. Anderson, West Haven.

10206. Wizard Brand. Sold by Pulverized Manure Co., Chicago, Ill. Stock of F. S. Platt Co., New Haven.

11350. Sheep Manure. Sold by E. J. Weckbach, Denver, Col. Sampled and sent by S. D. Woodruff & Sons, Orange.

11189. Sheep Manure. Brand unknown. Sampled and sent by Mrs. L. P. Wheeler, Westville.

10726. Sheep Manure. Brand unknown. Sampled and sent by M. H. Pratt, Hartford.

11126, from the Armour Fertilizer Works, failed to meet its guaranty in potash while the amounts of nitrogen and phosphoric acid considerably overran the guaranteed percentages. At the request of the Armour Works a second sample was drawn from a different lot, **11217,** which fully met the guaranty. Sheep manure cannot be expected to have a very uniform composition. Thus, in the 35 samples tested here in the last seven years, nitrogen has ranged from 1.0 per cent. to 2.74, phosphoric acid from 0.83 to 2.99, and water-soluble potash from 0.74 to 4.39 per cent. The *average* of all these analyses is

Nitrogen	2.09
Phosphoric acid	1.77
Water-soluble potash	2.43

ANALYSES OF SHEEP MANURE.

n No.	11126	11217	10735	11363	10817	11278	10206	11350	11189	10726
cent. of										
gen as nitrates	0.56	0.09	0.22	.....	.....	.....	0.10	.....	.....	.....
as ammonia	0.36	0.01	0.07	.....	0.30	.....	0.10	.....	.....	.....
as organic	1.30	1.45	1.29	.....	2.14	.....	1.84	.....	.....	.....
total found	2.22	1.55	1.58	2.50	2.44	1.92	2.04	1.36	2.20	1.95
total guaranteed	1.65	1.65	1.85	.....	2.25	.....	1.80	.....	.....	.....
horic acid, water-ible	0.45	0.04	0.09	.....	1.25	.....	0.38	.....	.....	.....
horic acid, citrate-ible	1.55	1.19	0.67	.....	0.37	.....	1.68	.....	.....	.....
horic acid, citrate-luble	0.49	0.14	0.14	.....	0.20	.....	0.10	.....	.....	.....
horic acid total found	2.49	1.37	0.90	.....	1.82	.....	2.16	.....	2.84	2.66
" total guaranteed	1.00	1.00	1.50	.....	1.25	.....	*	.....	.....	.....
r-soluble potash found	1.97	3.54	3.24	.....	2.07	.....	2.00	.....	1.36	.....
" " guaranteed	3.25	3.25	1.25	.....	1.50	.....	1.00	.....	.....	.....
ine	0.30	1.24	1.75	.....	0.58	.....	0.64	.....	.....	.....
per ton	$50.00	56.00	39.00	.....	45.00	.....	40.00	.....	.....	.....

Guaranty 1 per cent. "available."

11363 and **11350**, sent by S. D. Woodruff & Sons, and **10726**, sent by M. H. Pratt, Hartford, contain 41.62, 69.59 and 46.43 per cent. of mineral matter, sand and soil, respectively.

Obviously, such stuff is unfit for transportation from the West to Connecticut.

While sheep manure may be used in some cases in place of horse manure, in greenhouse work and on small lawns, it cannot profitably be used in farm practice, at any such prices as are charged at present.

RABBIT MANURE.

11359. Rabbit Manure. Sent by P. B. Burnett, Falls Village. It contained 1.02 per cent. of nitrogen in ammonia, 2.68 per cent. total nitrogen, 0.90 per cent. phosphoric acid and 1.11 per cent. of potash.

BAT GUANO.

11450 and **11451.** Bat guano from the bat caves, Isle of Pines, sent by Kopf Bros., New Haven. Analyses were as follows:

	11450	11451
Moisture	5.14	2.66
Ash	22.98	14.94
Organic and volatile	71.88	82.40
Total nitrogen	0.76	0.14
Phosphoric acid	8.88	4.64
Potash	1.42	0.00

ASHES.

Twenty-one samples of wood or other ashes have been analyzed and are included in table, page 165.

9699 is ashes from brass works sent to determine their agricultural value.

9750 is ashes from witch hazel brush which had been extracted in a witch hazel factory and then burned under the boilers.

9749 and **11356** are from the same factory, but are mixtures of wood and coal ashes.

11199 and **10595** were sent to determine their quality, before purchase.

10678 and **10677** probably do not represent material offered for sale but were sent with inquiry as to their value.

Only the following samples were drawn by the sampling agent of the Station—**11139, 11054, 9750, 9749, 10615, 10861, 10897.** Of these only three, **9750, 10615** and **10897,** can be classed as wood ashes of fair quality. A number of samples sent by individuals are also of good quality.

If we reckon lime as worth 50 cents per 100 lbs. and phosphoric acid at 6 cents, the water-soluble potash in **10861** cost about 35.6 cents per pound which at present potash quotations is not extraordinarily high.

LIME AND LIME-KILN ASHES.

9707. Slaked lime. Sold by the New England Lime Co., East Canaan. Sent by B. G. Southwick, Storrs.

11293. Lime. Sent by A. L. Chamberlain, New Haven.

9705 and **9706.** Lime Kiln Ashes made by the New England Lime Co., East Canaan. Sent by B. G. Southwick.

	9707	11293	9705	9706
Water-soluble potash	.....	.....	0.45	1.42
Lime	32.48	33.41	34.58	28.82
Magnesia	16.75	15.57	7.54	8.43

Station No.	Car No. and Dealer or Purchaser.	Water.	Insoluble in acid (sand).	Water-soluble potash.	Lime.	Phosphoric Acid.	Cost per ton.
11139	Alphano Humus Co., New York. M. M. Smith, Shaker Station	29.00	6.82	1.70	31.80	1.31	$18.00
11054	Amer. Agr. Chem. Co., New York. Milo Smith, Shaker Station	......	30.97	1.52	26.62	1.93	24.00
10675	Benjamin Betts, Fairfield	......	9.46	9.36	36.28	1.55	......
9699	Bristol Brass Co., Bristol, Conn. Frank S. Platt Co., New Haven	......	......	1.52	......	......	......
9750	E. E. Dickinson & Co., Essex, Conn	......	......	4.47	......	4.95	......
9749	E. E. Dickinson & Co., Essex, Conn	......	......	0.07	......	0.29	......
11356	E. E. Dickinson & Co., Essex, Conn	......	86.66	0.04	7.74	0.38	......
10984	Car 44354. The Griffin Tobacco Co., Hartford	......	12.59	6.03	32.70	2.35	......
11199	The Griffin Tobacco Co., Hartford	......	9.30	0.10	54.26	0.05	......
11276	Thomas Griswold Co., South Wethersfield	......	84.98	0.03	3.34	0.41	......
10985	John Joynt, Lucknow, Ont. The Griffin Tobacco Co., Hartford	......	14.09	6.10	32.68	2.23	......
10541	John Joynt, Lucknow, Ont. Henry Fuller, Suffield	......	16.30	4.88	30.59	2.17	......
10615	John Joynt, Lucknow, Ont. Henry Fuller, Suffield	......	17.48	4.67	30.73	2.19	39.00
10861	John Joynt, Lucknow, Ont. Hitchcock & George, Warehouse Point	......	45.56	1.33	10.81	0.68	26.00
10897	John Joynt, Lucknow, Ont. Henry Fuller, Suffield	......	10.69	6.54	33.29	2.30	*
10678	Patrick F. O'Brien, Willimantic	......	......	0.08	......	0.68	......
10677	Patrick F. O'Brien, Willimantic	......	......	0.95	......	0.13	......
10623	Olds & Whipple, Hartford. Car 21159. L. Wetstone, Vernon	......	10.46	6.24	30.50	2.30	*
9757	Samuel H. Reid, Suffield	......	18.60	2.40	†31.87	1.41	......
10815	Chas. Stevens, Napanee, Ont. John B. Cannon, Granby	......	9.50	6.75	39.44	1.94	30.00
10595	Sterling Asbestos Co., Brooklyn, N. Y. Barnes Brothers Nursery Co., Yalesville	......	11.49	5.58	41.52	2.33	......

*$6.50 per unit of potash.
† Magnesia, 3.74.

MUCK, PEAT, HUMUS, ETC.

Five samples have been examined as follows:

9996, 9997 and **9998.** Muck. Sent by A. B. Smith, Clintonville.

10516. Muck. Sent by Chas. Scheer, Kensington.

11342. Old deposit of vegetable matter underlying two feet of muck. Sent by E. Jay Teagarden, Danbury.

Station No.	9996	9997	9998	10516	11342
Composition as received:					
Water	63.03	69.03	72.86	65.31	72.88
Mineral matter	6.36	14.86	9.42	2.77	18.49
Organic matter	30.61	16.11	17.72	31.92	8.63
Nitrogen	0.76	0.40	0.45	0.32	0.25
Phosphoric acid	0.01	trace	trace	*	*
Potash	0.03	0.01	0.02	*	trace
On water-free basis:					
Mineral matter	17.20	47.98	34.71	7.99	68.18
Organic matter	82.80	52.02	65.29	92.01	31.82
Nitrogen	2.05	1.29	1.66	0.92	0.92
Phosphoric acid	0.03	.....	.....	.....	.....
Potash	0.08	0.03	0.07	.....	0.25

* Not determined.

The three samples having the highest per cent. of organic matter in their water-free state represent mucks which should have considerable value as absorbents in trenches and as material for composting with manure.

TOBACCO STEMS AND DUST.

Three samples were analyzed as follows:

10540. Tobacco Dust. Sent by Walter Mitchell, New Haven.

11434. Tobacco Dust. Sent by Morgan and Dickinson, Windsor.

9755. Tobacco Stems. Sent by the Shaker Farms, Enfield.

Station No.	10540	11434	9755
Nitrogen	1.32	2.24	1.86
Phosphoric acid	0.28	0.81	0.26
Potash (total)	1.62	3.09	3.55

LIME FERTILE AND NITRO-FERTILE.

These are two fertilizers made by the Fertile Chemical Co., Cleveland, Ohio, and entered for sale in this state. Their analyses follow:

11172. Nitro-Fertile, sent by the manufacturer.

11182. The same brand sent by the James Swan Co., Seymour.

10579. Lime-Fertile. Sent by the manufacturer.

10896. The same brand. Sampled from stock of A. R. Brewer, Hartford.

	11172	11182	10579	10896
Nitrogen as nitrates	2.36	2.24	....	....
Total nitrogen	2.36	2.24	0.02	....
Phosphoric acid	3.39	3.21	3.48	3.35
Water-soluble potash	4.26	4.04	0.05	....
Lime	....	....	42.14	....
Magnesia	....	....	8.80	....

Both materials are sold in small packages for household and greenhouse use.

MISCELLANEOUS MATERIALS.

10526. "Dust." Sent by D. H. Morgan, Southport, and stated to be a commercial product selling for $10.00 per ton.

11140. "Blower Dust." Sold by the Berkshire Fertilizer Co., Bridgeport. Sampled by Station Agent from stock of W. N. Pinney, Rockville. Price $37.50 per ton.

ANALYSES.	10526	11140
Total nitrogen	2.65	4.51
Phosphoric acid	1.02	10.13
Potash	1.03	0.40

9694. Marine Mud. Sent by J. W. Clark. Taken from the mouth of Oyster River, in Branford. It was asked whether the material had sufficient agricultural value to make it worth handling. It contained 54.11 per cent. of water and 41.02 per cent. of mineral matter, 0.16 of nitrogen and 0.08 of phosphoric acid. Obviously, material like this which contains 95 per cent. of valueless material cannot be profitably handled.

10841. Alphano Humus. Sent by Edith L. Gilbert, Kent, asking if it is as advertised in Ross Brothers Catalogue, a copy of which was sent with it.

It is there stated to be "a perfectly balanced soil ration that unfailingly produces immediate and long enduring fertility."

"The potash it contains alone is worth the price." The price quoted is $20.00 per ton.

It contained 2.21 per cent. of nitrogen, 1.16 of phosphoric acid and 0.08 per cent. of potash.

At current prices "the potash it contains alone is worth" about 56 cents.

In respect of the claim as to potash it is, therefore, not at all as advertised by the seller. His claim may not, however, be the same as that of the manufacturer.

10609 is a mixture of hen manure and acid phosphate, sent by W. N. Peck, Mt. Carmel.

10887 is soil from an old hen yard mixed with some ground limestone, sent by F. H. Saxton, Bristol..

ANALYSES.	**10609**	**10887**
Nitrogen as ammonia	0.21	....
Organic	1.20	....
Total	1.41	0.32
Phosphoric acid	5.64	0.58
Water-soluble potash	0.39	0.09

10697. Tea and Coffee Waste. A sample of material which had been exhausted in the preparation of caffein, sent by J. Carle & Sons, 153 Water St., New York., contained about 50 per cent. of water. It also contained 1.16 per cent. of nitrogen, 0.26 phosphoric acid and 0.31 per cent. of total potash.

10003. Copper in Horse Manure. Horse manure sent by C. M. Jarvis, Berlin, who reported that it did not heat readily. Sawdust had been used for litter in the stable from which the manure was bought. Copper was found in the manure which suggested that the stable had used for bedding sawdust from a factory where brass parts were cleaned by mixing sawdust with them in a tumbling barrel.

9747. "Potash from Feldspar." Feldspar treated in a furnace with magnesian limestone, coal dust and peat.

It contained 0.20 per cent. of nitrogen and 0.21 per cent. of potash soluble in acid. The treatment has obviously been of no marked effect in making the potash soluble.

10951. Treated Garbage. A sample of garbage specially treated to promote bacterial action. From Prof. S. C. Prescott, Mass. Institute of Technology.

11267. Sample from the Bridgeport Garbage disposal plant, sent by J. S. Holmes, Bridgeport.

	10951	11267
Nitrogen	0.85	1.00
Phosphoric acid	1.19	1.64
Potash	0.40	0.07
Insoluble in acid	56.32	....

The Bridgeport garbage contained

Water	30.35
Organic and volatile	22.86
Mineral matter	46.79
	100.00

OTHER MISCELLANEOUS SAMPLES.

Fifty samples of soil have been tested for lime requirement, and ten samples of various materials which seem to have no general interest are not further noticed in this report.

REGARDING THE CHEMICAL ANALYSIS OF SOILS.

The Station is constantly receiving samples of soil, ranging in size from a few teaspoonsful to a pint or more, taken from a garden or a particular field. The senders usually ask for an analysis which will show what elements of plant food are deficient or lacking in the soil, or they wish to know what crops can be most successfully grown on it. Analyses of such samples cannot furnish the information which is asked for.

Chemical analysis does not as a rule show with definiteness what a particular soil needs in the way of plant food to make it productive. An analysis shows the kind and quantity of the elements which are in a soil, but cannot show what elements and how much of them are readily available to crops. It is just this information, however, which we need.

With the rarest exceptions, our soils contain every element of plant food and in amount sufficient to produce many crops. Sometimes this food is not in sufficiently available form, but more often, other conditions prevent the crop from utilizing it. There may, moreover, be sufficient available plant food for some crops and not enough for others.

Experience teaches that the mechanical condition of the soil, its water-supply and water-holding capacity, its drainage, temperature

and aeration more largely affect the success of a crop than the chemicals or fertilizers added at planting time.

The good effects of stable manure, which are out of all proportion to the amount of plant food in it, are due in part to its effect on the other factors of fertility which have just been named.

If a soil is not sufficiently underdrained, if its mechanical condition is either too open or too close, or if it is not adapted to the particular crop which is being raised upon it, then it will not yield satisfactorily, no matter what fertilizers are applied to it. But on all these points a chemical analysis gives no information.

The trouble with many soils which give unsatisfactory returns being their physical condition rather than their chemical composition, it is as hopeless to search for the trouble by chemical analysis as it would be to try to determine why a man was unwell by a chemical analysis of a part of his body. If a soil is not sour, if it has the right texture, if it contains sufficient water and is not exposed to drought, if the weather conditions are favorable and the tillage is properly managed, then in most cases here in Connecticut fertilizers will give an increased yield, but if the conditions just mentioned are unfavorable, no amount of fertilizer will increase the crop.

The first thing to consider, if a soil is unproductive, is the water supply, which may be improved by irrigation, by thorough and intelligent tillage, and also by the increase of humus, which is to be secured from manure or by green manuring. Next, the probable need of lime should be regarded, and with it should always go more attention to increase of humus.

When all other factors of fertility have been made as favorable as possible, then and not till then should the question of the use of chemical fertilizers be considered.

Whether a soil is relatively deficient in quickly available potash, nitrogen, or other element of plant food, can best be determined by actual experiments made with the different forms of plant food on the land itself. Regarding such experiments this Station is prepared to offer suggestions to any who are willing to undertake them. This deficiency in available plant food cannot be determined by any chemical laboratory tests at present known.

Connecticut Agricultural Experiment Station

NEW HAVEN, CONN.

BULLETIN 210 JANUARY, 1919

BEING THE

Twenty-Third Report

ON

Food Products

AND

Eleventh Report on Drug Products

By E. M. BAILEY

The Bulletins of this Station are mailed free to citizens of Connecticut who apply for them, and to others as far as the editions permit.

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The Twenty-Third Report on Food Products and the Eleventh Report on Drug Products, 1918.

By E. M. Bailey.

The work of the past year, to which particular attention has been given, includes an inspection of market teas, complete analyses of some U. S. Standard teas, together with a study of certain analytical methods for the analysis of tea; the inspection and analysis of food oils and fats, including butter, oleo and nut margarines, and shortening materials other than lard; an inspection of soft drinks; analyses of a number of new cereal products including breakfast and health foods and substitute flours; and an increased volume of work for the Department of the Dairy and Food Commissioner, chiefly in the inspections of milk and olive oil. Some time has been devoted to the analyses of drugs and proprietary remedies.

As a war measure the services of the laboratory were placed at the disposal of the State Food Administrator for whatever co-operation we could render; and our assistance has been given more largely to local food administrators as well as health and police officials for the same reason.

An educational exhibit was prepared for the Department of Home Economics, State Council of Defense for use at the State Fair in Hartford.

Two examinations have been held in this laboratory for the accommodation of candidates for a milk and cream tester's license, as required by Chapter 221, Public Acts of 1917.

The writer has assisted the Director of this Station and the State Dairy and Food Commissioner in preparing a revision of the Rules and Regulations relating to the Food and Drug Law of this State; has served as referee on tea for the Association of Official Agricultural Chemists, and as expert on diabetic foods for the American Medical Association.

Since December, 1917, the department has been deprived of the service of Mr. Street, who entered the U. S. N. A. as a nutrition officer, and since August, 1918, of the service of Mr. Morison also, for a similar reason. The writer takes this opportunity to acknowledge the whole-hearted co-operation of the remaining members of the laboratory staff, Messrs. Shepard, D'Esopo and Edmund, and of Mr. Morison until his departure, in carrying on the work of the department.

I. FOODS.

TEA.

Origin. A Japanese legendary account of the origin of tea, is, according to Kaempfer,[1] as follows: "A priest who came from India into China in A.D. 519, having succumbed to sleep when he had wished to watch and pray, in a movement of anger cut off his two eyelids, which were changed into a shrub, the tea tree, whose leaves are eminently calculated to prevent sleep." Knowledge of tea, however, dates back much earlier than A.D. 519. It is mentioned as early as 2,700, B.C., and there is no doubt that its cultivation and use in China are of very ancient date. It is now cultivated in other countries of the Orient, notably India, Ceylon and Java, and in South America.

Definition. Tea is the leaves and leaf buds of different species of *Thea,* prepared by the usual trade processes of fermentation, drying and firing; meets the provisions of the Act of Congress approved March 2, 1897, and the regulations made in conformity therewith;[2] conforms in variety and place of production to the name it bears; and contains not less than four (4) nor more than seven (7) per cent. of ash.[3]

Botanical Character of Leaf. The characters of genuine tea leaf are sufficiently pronounced to make an examination of tea for foreign leaves not particularly difficult. The following are the characteristics of tea leaf as given by Leach.[4] The tea leaf is oval or lanceolate, 5 to 8 cm. long and 2 to 3 cm. wide. It is

[1] DeCandolle, Origin of Cultivated Plants.

[2] Treasury Department Circular No. 16, February 6, 1905.

[3] Definition, U. S. Department of Agriculture, Office of the Secretary, Circular No. 19.

[4] Food Inspection and Analysis, p. 286.

short-stemmed, somewhat thick and fleshy, attenuated at the bottom and usually pointed at the top. At a distance of a third to a quarter up from the base, the smooth or wavy margin of the leaf develops hooked-shaped serrations which continue to the tip. The veins extend outward from the midrib, nearly parallel with one another but before reaching the margin bend upward to join the one next above to form a loop.

Quality and Classification. The general quality of tea depends chiefly upon the age of the leaf, the time of picking and the method of preparation.

The youngest leaves are tenderest and most juicy and constitute the choicest product. Several pickings of leaves are made during a season, as many as 25 are said to be made in India, but leaves of pickings later than the second become tougher and less desirable in point of quality.

In case of Chinese teas, the significance of the name refers to the position of the leaf on the branch. Thus *flowery pekoe* is composed of the newest leaf on the tip of the branch. This class of tea is seldom found outside the country of its production. The next leaves in descending order on the branch constitute *orange pekoe, pekoe, souchong 1st* and *2d,* and *congou.* The seventh leaf, if there be one and it is used, is termed *Bohea.* Teas are also designated by the name of the district of their production.

The difference between black and green teas is not one of variety but of method of preparation. Black teas are fermented before drying. This process destroys the chlorophyll, to which the color of green tea is due, and partially decomposes tannin as shown by Kozai's[1] analyses. Green teas are dried while still fresh and unfermented. Tea infusions are prized for their peculiar aroma, flavor and stimulating effects, to which essential oil, tannin and thein chiefly contribute. Thein is the alkaloid of tea and is identical with the caffein of coffee.

Production. In 1860 by far the greatest amount of tea imported by the United States came from China. The quantity coming from Japan has increased enormously since that time, advancing from 35,000 lbs. in 1860 to more than 37,000,000 lbs. in 1896, in which year it equalled the amount coming from China. In 1917 the United States imported 126,794,997 lbs. of tea, valued at $25,-763,075, of which 41% came from Japan, 25% from the British

[1] Imperial College of Tokyo, Japan, Bull. 7.

East Indies, 15% from China, and the remainder from the United Kingdom, Canada and other countries.[1]

Legislation. The quality of teas imported into the country was safe-guarded in 1883 by an Act of Congress, which act was repealed and replaced by a broader act entitled "An Act to prevent the importation of impure and unwholesome tea," approved March 2, 1897. Under this law the Secretary of the Treasury is charged with the enforcement of the provisions of the Act. He is required to appoint each year a board of seven experts who shall prepare and submit to him standard samples of tea. Upon the recommendation of this board he shall fix and establish uniform standards of purity, quality and fitness for consumption of all kinds of teas imported into the United States. Duplicate samples of such standards are deposited at the Custom Houses of New York, Chicago and San Francisco and such other places as he may determine. These serve as a basis of comparison and judgment for teas of their respective classes.

By an amendment to Sec. 1 of this Act, approved May 16, 1908, the importation of low grade tea is permitted "for the sole purpose of manufacturing theine, caffeine or other chemical products whereby the identity and character of the original material is entirely destroyed or changed."

Regulations made by authority of the Act provide for the comparison of suspected or other teas with the standards, according to the usage and custom of the tea trade. Teas are judged for quality, for impurity, including coloring or facing, and for quality of infused leaf. An excess of woody stems (floaters) over the amount shown by its respective standard is basis for the rejection of any tea. The presence of artificial coloring or facing is not of itself sufficient ground for rejection, but only when such coloring or facing occurs in amounts to exceed that of the respective standard. For this comparison the Read test, as amended, Treas. Dept., May 16, 1918, is recognized as official.

Teas comparing unfavorably with the standards as regards the points above mentioned, should be further submitted to chemical analyses in comparison with the standards.

Inspections in this State. An examination of teas found in the Connecticut market, made in this laboratory in 1898, showed

[1] Tea and Coffee Trade Journal, April, 1918.

practically no adulteration or inferiority. Foreign leaves were found in one sample and many green teas were "faced," but this, as shown above, does not of itself constitute adulteration under the tea Act. No inspection of tea has been made since that date, but this satisfactory condition of the market has apparently continued, as indicated by our inspection this year.

INSPECTION OF 1918.

Number of Samples examined. In connection with the examination of 44 samples of market teas, more complete analyses of the 12 U. S. Government Standard Teas for 1918-1919 were made.[1] The laboratory was in possession of 8 teas which were the U. S. Government Standard for 1905-1906, the same having been kept in the original unbroken package since that year. These also were analyzed.

EXPERIMENTAL WORK.

Methods. The analytical methods used were the revised methods as given in the Jour. A. O. A. C. Vol. II, No. 3, p. 335 et seq. A slightly modified procedure was followed for the estimation of *water extract* and particular attention was given to the determination of *caffein* (theine) in a number of standard teas.

Hot water extract. The amount of water extractives to be obtained from tea will obviously depend chiefly upon the proportion of water used and the length of time of boiling. Lesser variations will be introduced by the methods of filtering and the use of tarred papers and weighing bottles.

The tentative method for determining water extract is as follows:

To 2 grams of the original sample in a 500cc Erlenmeyer flask, add 200cc of hot water and boil over a low flame for an hour. The flask should be closed with a rubber stopper through which passes a glass tube 18 inches long, for a condenser. The loss from evaporation should be replaced from time to time by the addition of hot water. Filter through a tared filter and wash the residue until the filtrate measures 500cc, stirring the contents of the filter throughout the process to facilitate the filtering. Dry

---

[1] Through the courtesy of Mr. Geo. F. Mitchell, Supervising Tea Examiner, and of the Collector of the Port of New York, the laboratory was furnished with a set of the U. S. Standard Teas for 1918-1919. Other courtesies by Mr. Mitchell are furthermore gratefully acknowledged.

the filter paper and residue in the funnel in the steam oven until the excess of water is removed, transfer paper and contents to a tared weighing bottle and dry to constant weight at 100° C.

This procedure was found to be extremely slow and tedious, due to the clogging of the filter and consequent slow filtration. It was suggested[1] that an adaptation of the procedure now used in this laboratory for the determination of crude fiber be tried.

This procedure as adopted is as follows:

To 2 grams of the original (unground) sample in a 500 cc Erlenmeyer flask add 200 cc of hot water and boil for an hour, having the flask fitted with a glass tube condenser. Replace water lost by evaporation if necessary. Fill the flask with cold water and allow suspended material to settle. Draw off the supernatant liquid, filtering same through a linen filter. (An inverted thistle tube or other suitable tube, over the orifice of which is tied a piece of fine linen introduced into the Erlenmeyer and connected with suction serves the purpose satisfactorily). The residue in the flask is then thrown upon a tared filter, allowed to drain and washed three times with water. Dry out in the funnel until excess of water is removed, finally transferring filter and contents to a tared weighing bottle and drying to constant weight at 100° C.

The per cent. of insoluble leaf, plus the per cent. of moisture in the sample, subtracted from 100 per cent., gives the per cent. of hot water extract.

The essential conditions of the tentative method are not materially changed but the slow filtration is avoided.

The comparison is shown in the following tabulation:

TABLE I. HOT WATER EXTRACT IN TEA.

No.	Tentative Method %.	Modified Method %.	Difference by Modified Method %.
10517	38.12	38.09	—0.03
10518	35.04	35.15	+0.11
10519	29.56	29.05	—0.51
10520	32.13	32.63	+0.50
10521	35.36	35.49	+0.13
10522	36.13	36.75	+0.62
10523	33.02	33.27	+0.25
10524	35.08	35.60	+0.52

The results obtained by the modified procedure are generally higher than those by the tentative method, but the differences are within the limits of reasonable toleration of error for a determination of this kind; *viz.*, 1 per cent.

[1] By C. E. Shepard.

It is interesting to note that the present tentative method was suggested by Doolittle and Woodruff[1] who used for their investigations, as we have in ours, the standard teas of 1905–6. The amounts of extract obtained by them run from 6 to 9 per cent. higher than the figures given in Table I above, which is due to the fact that they undoubtedly used the ground sample, while we have used the unground tea.

Caffein. In 1890 G. L. Spencer[2] used a method for the determination of caffein in tea which was essentially the Stahlschmidt procedure. He adopted it for its simplicity and accuracy. The Stahlschmidt method as modified by J. M. Bartlett[3] in 1915 is the present tentative method for caffein.

Comparative studies with this method and one due to Fendler and Stuber[4] have been made on a number of standard teas.

The method of Fendler and Stuber is as follows:

Pulverize the tea to pass without residue through a 0.5 mm. sieve.

Treat a 10 gram sample with 10 grams of 10% ammonium hydroxide and 200 grams of chloroform in a glass-stoppered bottle and shake continuously for one-half hour. Pour the entire contents of the bottle on a 12½ mm. folded filter, covering with a watch-glass. Weigh 150 grams of the filtrate into a flask (250 cc) and evaporate on a steam bath, removing the last chloroform with a blast of air. Digest the residue with 80 cc of hot water for ten minutes on the steam bath, with frequent shaking, and let cool. Treat the solution with 20 cc of 1% potassium permanganate and let stand one-quarter hour at room temperature. Add 2 cc of 3% hydrogen peroxide (containing 1 cc glacial acetic acid in 100 cc). If the liquid is still red or reddish, add hydrogen peroxide, 1 cc at a time, until the excess of potassium permanganate is destroyed. Place the flask on the steam bath for one-quarter hour, adding hydrogen peroxide in ½ cc portions until the liquid becomes no lighter in color. Cool and filter into a separatory funnel, washing with cold water. Extract four times with 25 cc of chloroform. Evaporate the chloroform extract from a weighed flask with the aid of an air blast and dry at 100° C. Weigh the residue as caffein and calculate to 7.5 grams of tea. Test the purity of the residue by determining nitrogen and multiplying by the factor 3.464.

Six of the standard teas of 1918–19 were used in these trials. The results are given in Table II.

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[1] Proceedings A. O. A. C., 1906. Bureau Chem. Bull. 105, p. 48.

[2] Bureau of Chem. Bull. 13, Part VII., 1890.

[3] Jour. A. O. A. C. **3.** 1, p. 22., 1917.

[4] Zeit. Nahr.-u. Genussm., **28,** 9, 1914.

TABLE II. DETERMINING CAFFEIN IN TEA.

Station No.	Name and Standard No.	Modified Stahlschmidt Method. Gravimetric.		Fendler and Stuber Method. Gravimetric.	
		Gravimetric.	From N.	Gravimetric.	From N.
		%	%	%	%
11205	Formosa Oolong, 1.....	2.20	2.03	2.16	2.12
11206	Fouchow Oolong, 2....	2.54	2.44	2.57	2.54
11207	Congou, 3............	1.97	1.89	1.97	1.93
11211	Pan Fired Japan, 7.....	2.00	1.94	2.07	2.00
11214	Scented Orange Pekoe, 10	2.71	2.63	2.82	2.73
11216	Canton Oolong, 12.....	3.10	2.96	3.27	3.20

The results indicate a slightly higher degree of purity in the caffein obtained by the Fendler and Stuber method. The figures by this method are also seen to be uniformly higher although the differences do not exceed 0.1 per cent. except in one instance, which may be due to a greater experimental error in that case.

Comparative studies of these two methods in the case of coffee[1] showed generally but not uniformly lower results by the Fendler and Stuber method.

The difficulties attending the weighing of volatile solvents at midsummer temperatures, such as obtained when our work was done, tend to errors in the plus direction. We prefer the Stahlschmidt method for its simpler manipulation and greater uniformity of results under varied conditions.

It is interesting to refer again to results obtained by Doolittle and Woodruff[2] on U. S. Standard Tea No. 4 of the 1905-6 standards, using the Stahlschmidt method. They report duplicate results of 2.38 and 2.28 per cent. thein. Our own gravimetric result on this sample is 2.34 per cent. The moisture content of their sample was 9.26 and of ours at this time 7.78 per cent., so that on a water-free basis the results are practically identical.

Proportion of caffein and tannin removed from tea by household methods of infusion. The value of tea as a beverage depends obviously upon the ingredients of the leaf which are removed by the method of infusion. The constituents of tea have not been sufficiently studied to enable us to interpret the physiological effects of the beverage in terms of definite chemical ingredients. Generally the stimulating quality is attributed to caffein, and the peculiar shades of taste and aroma to the tannin and essential oils, the latter being present, however, in exceedingly small amounts.

We have made a series of determinations to show how much of the caffein and tannin is removed by a process of infusion which is probably generally typical and which is recommended by an expert on India teas.[1]

The method is as follows:

One heaping teaspoonful of tea is taken for each cup of water. Bring the water to boiling, add the tea and remove from the flame at once to stop boiling. Allow to steep for 4 minutes and strain.

For analytical purposes this method was reduced to more definite proportions. It was found by trial that a heaping teaspoonful of tea weighed about 4 grams. A cup full of water is taken to be a half pint or 240 cc. After straining, the tea solution was cooled and made up to a volume of 250 cc. Aliquot portions were taken for determination of solids, caffein and tannin.

Solids obtained by evaporating an aliquot of the tea infusion were found to be lower than when obtained by difference, as directed in the methods for hot water extract. It was found by a series of trials that this difference averaged close to 10 per cent. The figures for extract in the accompanying table have, therefore, been increased by 1/10 to make them more strictly comparable with the extract as obtained by the regular laboratory methods.

The results of this experiment are shown in Table III as compared with the total amounts of the several constituents obtained by regular methods of analysis.

TABLE III. PERCENTAGE AMOUNTS OF EXTRACT, CAFFEIN AND TANNIN OBTAINED FROM TEA BY A HOUSEHOLD METHOD OF INFUSION.

No.	Extract. Total	Extract. Household Method.	Extract. Percent. of total.	Caffein. Total.	Caffein. Household Method.	Caffein. Percent. of total.	Tannin. Total.	Tannin. Household Method.	Tannin. Percent. of total.
11205	35.80	19.32	54.0	2.03	1.80	88.7	7.95	4.37	55.0
11206	36.38	19.18	52.7	2.44	2.08	85.2	9.78	4.28	43.8
11207	30.01	13.84	46.1	1.89	1.64	86.8	4.02	1.48	36.8
11208	33.65	20.57	61.1	2.77	2.32	83.8	6.83	3.67	53.7
11209	33.25	17.69	53.2	1.73	1.52	87.9	5.76	2.79	48.4
11210	32.00	12.91	40.3	1.54	1.42	92.2	5.85	3.05	52.1
11211	34.82	21.56	61.9	1.94	1.81	93.3	8.21	5.07	61.8
11212	32.91	18.77	57.0	2.01	1.93	96.0	7.51	4.10	54.6
11213	42.12	28.64	68.0	1.94	1.87	96.4	7.60	6.59	86.7
11214	38.90	23.32	60.0	2.63	2.32	88.2	10.75	5.33	49.6
11215	37.59	20.17	53.7	2.81	2.44	86.8	10.92	4.28	39.2
11216	36.69	19.36	52.8	2.96	2.77	93.6	10.48	4.28	40.8

[1] See Kinney & Cooley. Foods and Household Management.

It should be noted that **11213** is tea dust, which explains the higher percentage of total water extract and also the higher proportions of extract, *caffein* and tannin removed by the household method. From the data, excluding **11213,** it appears that from 84 to 96 per cent. of the caffein in the tea leaf finds its way into the tea-cup by the ordinary method of household preparation. Also it appears that only 37 to 62 per cent. of the tannin, and 40 to 62 per cent. of the total extractive matter are removed. In other words, the percentage removal of tannin nearly equals the removal of total extractives. This is in substantial agreement with results obtained by Kenrick[1] by a 10 minute infusion process.

Proportion of stems. Besson[2] in an examination of Chinese, Ceylon, Java and Indian teas found percentages of stalks as follows:

Chinese green	0.4 to 5.3
Chinese Foochow	4.1 to 17.5
Chinese Hankow	8.6 to 17.1
Ceylon	5.8 to 43.4
Indian	11.5 to 37.4
Java	4.4 to 29.9

He found very little relation between the amount of stalk and the quality of the teas, as judged by the test of taste and by the price.

Deuss,[3] following Besson's method, found from 7.3 to 9.3 per cent. stalk in Japanese teas and from 3.6 to 28.3 per cent. in Java teas. He suggests that it is justifiable to fix standards for the amount of stalk in teas, but thinks it should not be so low as the Swiss standard; *viz.,* 22 per cent.

The separation of stems and leaves is a mechanical process carried out as follows:

Boil 5 grams of the original tea with 200 cc of water for 15 minutes, decant the aqueous extract and bring the insoluble material into a suitable dish with 50 cc of fresh water. Pick out the stems with forceps, dry at 100° and weigh. The botanical character of the leaf can well be observed during the operation of separating the stems.

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[1] Canada Inland Rev. Dept. Bull. 24, 1891.

[2] A. A. Besson. Chem. Zeit., **35,** 813-815; 830-832, 1911. (Through Analyst, **36,** 454, 1911.)

[3] J. J. B. Deuss. Chem. Weekblad, **13,** 66-71, 1916. (Through Analyst, **41,** 78, 1916.)

There is some question as to what should properly be included in the term "stems;" whether it should include all stems or bits of stems to which no portion of leaf blade is attached, or whether it should refer to the more distinctly woody fragments and floaters. The latter, obviously, are the elements which would, in excess, noticeably affect the substance and quality of the product. We have followed the former plan, although it is open to the criticism that it includes elements which were parts of leaves and have been broken therefrom in the process of manufacture.

The results, tabulated in detail in Table IV, show that the per cent. of stems ranges from 2.58 to 15.20, omitting the sample of tea dust in which the amount of stems was only 0.14 per cent. No consistent relation is shown between the amount of stems and the amounts of such other constituents as hot water extract, nitrogenous material, fiber, caffein and tannin, except that sample **11210** having 15.20 per cent. of stems, had the lowest nitrogen content in the series and the highest fiber content. This sample was noted to have a larger proportion of woody stems than any other in the series.

ANALYSES OF U. S. STANDARD TEAS.

The complete analyses of eight of the U. S. Standard teas of 1905–6 and a complete set of the standard teas of 1918–19 are given in Table IV.

The official definition of tea includes only one numerical standard; *viz.*, not less than four (4) nor more than seven (7) per cent. of ash.

The standard teas examined fall within these limits, except in the case of **10522,** which contained 7.43 per cent., 4.11 being insoluble in water, of which a relatively high amount, 0.82 per cent., was insoluble also in acid. Nos. **10524** and **11213** also contained high proportions of ash insoluble in acid, the total ash, however, not exceeding the maximum of 7 per cent.

As regards the relation between the water-soluble and water-insoluble ash, the former exceeds the latter in eleven out of twenty samples. In no sample did the water-soluble ash equal 4 per cent. In fourteen samples it exceeded 3 per cent., and of the remaining six only one was less than 2.5 per cent.

TABLE IV—ANAL

Station No.	Name of Tea and Standard No.
	1905-1906.
10517	Formosa Oolong, 1
10518	Foochow Oolong, 2
10519	North China Congou, 3
10520	South China Congou, 4
10521	India, 5
10522	Ping Suey, 6
10523	Country Green, 7
10524	Pan Fired Japan, 8
	1918-1919.
11205	Formosa Oolong, 1
11206	Foochow Oolong, 2
11207	Congou, 3
11208	Ceylon, 4
11209	Gunpowder Green, 5
11210	Young Hyson Green, 6
11211	Pan Fired Japan, 7
11212	Basket Fired Japan, 8
11213	Japan Dust, 9
11214	Scented Orange Pekoe, 10
11215	Scented Canton, 11
11216	Canton Oolong, 12

* cc $\frac{N}{10}$ alkalai per gram of tea.

Total nitrogen ranges from 2.95 to 4.22 per cent. By far th greater part of this nitrogenous material remains to be identifie

Substances soluble in ethyl ether are lower than the averag of published analyses which we have seen. These results we obtained by a sixteen-hour continuous extraction of the materi previously dried in hydrogen.

While there is no standard for hot water extract, teas yieldin less than 30 per cent. thereof are generally regarded as inferio The extract in all the standard teas of 1918-19 exceeded 30 pe cent.; in six it exceeded 35 per cent.; in only one, Japan Dus did it exceed 40 per cent.

The analyses of the two series of teas is interesting, first f the comparison between crops of widely separated years an second, as showing that practically no change, as revealed b analysis, takes place in tea properly stored during a period

'ANDARD TEAS.

Moisture.	ASH Total.	Sol. in Water.	Insol. in Water.	Insol. in Acid.	Alkalinity of Sol.	Alkalinity of Insol.	P_2O_5 Soluble.	P_2O_5 Insoluble.	Total Nitrogen.	Crude Fiber.	Ether Extract.	Hot Water Extract.	Caffein. Gravimetric.	Caffein. From Nitrogen.	
%	%	%	%	%	*	*	%	%	%	%	%	%	%	%	(
7.12	6.16	3.32	2.84	0.56	2.6	3.5	0.29	0.41	3.75	11.37	1.17	38.12	2.36	2.22	9
7.43	6.21	3.09	3.12	0.60	3.2	3.9	0.17	0.46	3.12	13.09	1.79	35.04	2.22	2.06	8
3.79	5.77	3.21	2.56	0.29	3.0	4.1	0.23	0.43	3.60	11.55	1.44	29.56	2.36	2.32	6
7.78	5.85	3.32	2.53	0.32	3.2	3.6	0.17	0.38	3.39	12.68	0.96	32.13	2.34	2.20	6
7.20	5.96	3.76	2.20	0.02	3.0	5.2	0.23	0.52	4.04	10.82	2.11	35.36	3.55	3.27	7
7.12	7.43	3.32	4.11	0.82	3.3	3.9	0.51	0.46	3.33	11.85	1.95	36.13	1.79	1.73	6
7.12	5.78	3.35	2.43	0.09	3.7	4.7	0.20	0.49	3.27	13.53	1.92	33.02	1.94	1.85	7
3.73	6.94	3.21	3.73	0.85	3.4	4.3	0.24	0.46	3.59	13.04	1.84	35.08	1.87	1.78	7
7.07	6.40	2.99	3.41	0.32	2.8	3.9	0.14	0.37	3.30	13.91	2.32	35.80	2.20	2.03	7
3.53	5.57	2.99	2.58	0.12	3.1	3.5	0.18	0.36	3.22	13.96	2.96	36.38	2.54	2.44	9
5.21	6.15	2.75	3.40	0.72	2.8	4.0	0.14	0.38	3.04	14.47	2.19	30.01	1.97	1.89	4
7.80	6.23	3.28	2.95	0.35	3.5	4.0	0.12	0.52	3.68	13.08	1.51	33.65	2.96	2.77	6
7.79	6.73	3.31	3.42	0.53	3.5	4.1	0.05	0.48	3.18	14.30	4.44	33.25	1.86	1.73	5
3.17	6.51	2.16	3.35	0.51	3.8	4.1	0.11	0.45	2.95	17.28	3.33	32.00	1.68	1.54	5
3.88	5.70	2.80	2.90	0.47	3.2	4.0	0.14	0.48	3.39	15.37	4.22	34.82	2.00	1.94	8
7.52	5.74	3.08	2.66	0.18	3.8	4.3	0.01	0.50	3.39	15.87	4.70	32.91	2.07	2.01	7
7.78	6.73	3.19	3.54	0.96	3.8	4.0	0.19	0.45	3.47	13.25	4.14	42.12	2.09	1.94	7
7.58	5.77	3.19	2.58	0.18	3.5	3.8	0.44	0.41	4.04	13.36	2.05	38.90	2.71	2.63	10
3.56	5.99	3.42	2.57	0.30	3.7	3.6	0.30	0.40	4.22	11.83	2.43	37.59	2.93	2.81	10
7.12	5.19	2.94	2.25	0.20	3.3	3.6	0.26	0.31	3.78	13.17	2.01	36.69	3.10	2.96	10

twelve years. The lower ether extract in the older teas is not readily explained. Slow volatilization of the essential oils affords a partial explanation.

INSPECTION AND ANALYSIS OF MARKET TEAS.

Forty-four samples of market teas, mostly of cheaper grades, have been examined.

The results of the examination are shown in Table V.

It is seen that the limitations of the standard as regards ash are met with but one exception, and in that case the maximum is exceeded by only 0.05 per cent.

Hot water extract exceeds 40 per cent. in seven cases and exceeds 35 per cent. in forty-three cases of the total of forty-four.

Ether extract is lower in black tea than in green tea, as would be expected from the fact that chlorophyll, which comprises a

TABLE V. ANALYSES OF MARKET TEAS.

Number.	Brand.	Price Per lb.	Moisture.	Ash.	Total Nitrogen.	Ether Extract.	Fiber.	Hot Water Extract.
		cents.	%	%	%	%	%	%
9962	Black	60	7.52	5.73	3.48	2.53	11.62	36.72
9961	“	45	5.64	5.85	3.91	1.91	10.82	39.11
9946	“	40	5.56	6.30	3.57	2.35	11.74	38.06
9947	“	50	5.35	6.08	3.57	2.68	12.60	38.32
9948	“	55	5.42	6.04	3.81	1.40	11.09	40.76
9949	“	39	4.07	7.05	3.50	2.07	13.01	39.63
9950	“	50	5.61	5.93	3.26	2.39	12.82	37.46
9951	“	60	5.61	6.66	3.76	2.51	13.47	34.73
9952	“	50	6.24	6.00	3.61	1.40	11.75	40.13
9953	“	35	4.51	6.41	3.57	2.25	12.04	35.63
9954	“	40	4.49	6.38	3.53	2.21	13.36	38.56
9955	“	40	4.73	6.25	3.81	2.59	11.87	35.30
9956	“	55	4.61	6.25	3.78	1.96	11.38	41.08
9957	“	50	4.23	6.28	3.56	1.93	12.31	39.19
9958	“	33	5.40	6.44	3.49	2.55	12.42	36.79
9959	“	55	5.79	5.37	3.70	1.46	12.05	34.14
9960	“	45	5.99	5.98	4.11	1.08	9.97	39.54
9968	Black, Ceylon	80	6.51	5.52	4.04	1.27	10.62	37.42
9965	Green	40	6.50	5.73	3.56	3.06	13.19	35.14
9971	“	35	4.70	6.00	3.78	3.59	13.39	35.73
9972	“	60	4.61	5.60	3.66	3.55	13.68	37.48
9973	“	35	5.03	5.83	3.40	4.22	14.41	37.34
9974	“	33	4.69	5.65	3.69	3.57	13.91	37.20
9975	“	50	5.85	5.50	3.64	3.82	12.72	36.22
9978	“	35	5.00	5.75	4.09	3.23	13.64	39.00
9979	“	45	4.70	5.61	4.38	2.71	11.25	40.47
9980	“	50	5.72	5.55	3.52	4.31	14.06	36.07
9981	“	35	4.83	5.80	3.42	3.90	15.37	35.09
9982	“	45	3.91	5.88	4.26	2.65	11.42	40.18
9983	“	45	4.80	6.62	3.94	3.85	10.48	39.15
9984	“	39	4.80	6.46	3.94	2.50	10.27	38.32
9985	“	45	5.18	5.50	4.20	2.90	12.02	38.20
9986	“	50	3.88	5.71	4.29	2.81	11.84	41.32
9987	“	45	5.61	6.48	3.26	2.92	13.94	43.99
9988	“	40	5.08	5.75	3.50	3.29	14.90	36.97
9989	“	50	4.97	5.22	3.92	2.60	11.97	38.63
9977	Green, Gunpowder	50	5.13	6.23	3.72	2.79	10.10	39.37
9964	Mixed	75	6.97	5.94	3.72	1.99	11.58	36.73
9966	“	60	5.89	5.99	3.44	3.18	12.10	38.78
9967	“	60	6.54	6.18	3.88	1.20	11.12	37.44
9969	“	70	6.49	5.41	3.98	1.29	9.48	39.97
9970	“	70	7.58	5.19	3.25	1.35	10.64	36.25
9963	Orange Pekoe	80	5.95	5.61	3.99	1.49	11.20	37.77
9976	Uncolored Japan	50	6.30	5.55	4.09	2.56	12.81	38.42

large portion of such extract, is largely destroyed in the process by which black tea is made.

No foreign leaves were detected in any of the samples.

As regards conformity to standard, quality and genuineness of leaf, this inspection reveals a very satisfactory condition of the tea market.

Fats and Oils.

Some of the work done with this class of foods has already been reported.[1] Subsequent work includes an inspection of olive oil, and further analyses and inspections of butter, oleomargarine, nutmargarine and cooking fats. The greater part of the newer work is upon samples submitted by the Dairy and Food Commissioner.

OLIVE OIL.

Six inspections of olive oil, made by this Station between the years 1897 and 1909, both inclusive, showed a general improvement as regards adulteration, indicated by the following tabulation:[2]

Table VI.—Summary of Inspections of Olive Oil.

	Year.	Not found adulterated.	Adulterated.	Per cent. adulterated.
From Grocers	1897	37	23	38.3
	1900	45	28	38.4
	1905	19	0	0.0
	1906	25	0	0.0
	1907	7	0	0.0
	1909	44	0	0.0
From Druggists	1897	13	5	27.8
	1900	17	13	43.4
	1905	21	9	30.0
	1906	55	11	16.7
	1907	65	11	14.5

Owing to unusual trade conditions during the past year, many dealers have resorted to mixing less expensive oils, like cottonseed and corn oils, with olive oil, neglecting to legalize such a mixture by proper labelling and neglecting also to reduce the price proportionally.

[1] Conn. Agr. Exp. Station Bull. 201, Jan., 1918.

[2] Conn. Agr. Exp. Station Report, 1909–10, p. 214.

Ninety-eight samples were examined. Of these, three were either sold for mixtures or legally labeled to declare the presence of foreign oil. Twenty-five were sold for olive oil but contained cottonseed oil. Two were sold for olive oil but were largely corn oil. Of the adulterated samples containing cottonseed oil one was marked Pompeian Brand, but it was admitted at the trial of the dealer that the oil was bought in bulk and retailed, in this case, in a refilled can. Another sample, although the presence of cottonseed oil was declared, was not labelled in accordance with the Rules and Regulations provided in such cases.

All violations of the law were investigated by the Dairy and Food Commissioner, who, upon affidavits of this laboratory, held twenty-seven hearings which were followed by twenty-three prosecutions.

The results of this inspection are given in Table VII.

Three samples were sent in by individuals. **11143** was adulterated with cottonseed oil. **10785** appeared to be genuine olive oil but contained a sediment and had a musty odor. **11258**, *Sierra Madre* brand, a California oil packed for Goldberg, Bowen & Co., San Francisco, was found to be pure. It had an iodine number of 87.2 and a refractive index of 1.4710 at 15.5° C.

COOKING FATS.

Analyses of a number of cooking fats have been reported in an earlier bulletin.[1] To this list the analysis of Sawtay has been added. This product, like Kuxit, shows the chemical and physical constants of cocoanut fat.

The sample of Mazola examined gave a Reichert-Meissel number of 0.86. Subsequent samples examined gave lower results, none exceeding 0.15. Referring to the literature on the volatile fatty acids of corn oil, Volte and Gibson[2] obtained Reichert numbers of 4.2 to 4.3 which would be closely equivalent to Reichert-Meissel numbers of 8.4 to 8.6. Spüller obtained a Reichert figure of 0.33 (R-M 0.66) and Hopkins[3] obtained a Reichert-Meissel number of 0. Hopkins and Coburn[4] have reported Reichert-

[1] Conn. Agr. Exp. Station Bull. 201, Jan., 1918.
[2] J. Am. Chem. Soc., **22**, 461, 1900.
[3] J. Am. Chem. Soc., **20**, 956, 1898,
[4] Oil Chemists' Handbook, 1900, p. 38

TABLE VII. INSPECTION OF OLIVE OIL.

Number.	Brand.	Dealer.	Price per gal.	Refractive test Index @ 15.5.	Halphen test for cottonseed oil.	Baudouin test for sesame oil.	Nitric Acid test for corn oil.
	Not Found Adulterated						
		ANSONIA:					
13474	Rivera. Packed in Malaga, Spain	Geo. Gardello	$3.20	1.4705	negative	negative	negative
13475	Pericles	G. A. Kledaras	4.80	1.4705	negative	negative	negative
13465	Rome Superfine	Mariania Romano	5.20	1.4708	negative	negative	negative
		BRIDGEPORT:					
13497	Romanza. Misura Esatta	Joseph M. Calcaterra	4.00	1.4708	negative	negative	negative
13485	Domino Extra. Virgin Imported, Internationala, Chicago	L. Mainiero	4.40	1.4706	negative	negative	negative
13489	Gloria. Gloria Olive Oil Co	Joe Minarda	5.00	1.4703	negative	negative	negative
13499	Red Lion. T. C. Dolea Co., Porta Maurizio, Italy	Fuse & Perachio	5.40	1.4705	negative	negative	negative
13484	Romanzo. The Romanilli Co., Genoa, Italy	J. E. Roberts	5.00	1.4706	negative	negative	negative
13116	In bulk	Antonio Russo	......	1.4706	orange*	negative	negative
13490	Gloria. Gloria Olive Oil Co	J. Simonelli	5.00	1.4703	negative	negative	negative
13470	Mariani, M. B. Imported San Remo, Italia	Sam Vindigni	4.40	1.4705	negative	negative	negative
13498	Phoenix	Tony Vontsos	5.00	1.4708	negative	negative	negative
		DANBURY:					
13493	Beaumarchand. Nice	W. D. Baldwin	5.40	1.4705	negative	negative	negative
13494	Soprafino, Marca Roma	D. Gillotti	4.00	1.4705	negative	negative	negative
13492	Purity Superfine. Packed in Italy	Gigliotti Bros	5.00	1.4703	negative	negative	negative
		FAIRFIELD:					
13496	Italy Pure. Philip Berio & Co., Lucca, Tuscany	D. Mercurio	5.60	1.4702	negative	negative	negative

* Suspicious, but passed.

TABLE VII. INSPECTION OF OLIVE OIL—*Continued.*

Number.	Brand.	Dealer.	Price per gal.	Refractive test Index @ 15.5	Halphen test for cottonseed oil.	Baudouin test for sesame oil.	Nitric Acid test for corn oil.
	Not Found Adulterated—Continued.	HARTFORD:					
13122	Elysee Palace, Virgin	V. Bonelli	......	1.4704	negative	negative	negative
13121	Passo	V. Bonelli & Son	......	1.4704	negative	negative	negative
13454	Gloria Virgini. Gloria Olive Oil Co., Italy	Louis Both	$4.00	1.4705	negative	negative	negative
13836	In bulk	M. J. Cunningham	......	1.4706	negative	negative	negative
13120	Romanzo	R. Delillo	......	1.4704	negative	negative	negative
13456	Valca. Cavanna & Co., Importers, Philadelphia, Pa	H. Ladone	5.00	1.4704	negative	negative	negative
13119	Spanish	G. Martello	......	1.4702	negative	negative	negative
13117	In bulk	Vincenzo Juliano	......	1.4703	negative	negative	negative
13455	Mariani	B. D. Pasquale	4.00	1.4710	negative	negative	negative
		MERIDEN:					
13491	Virgin Oil. F. Valenti, New York, Importer	D. Dondero	5.00	1.4703	negative	negative	negative
		MIDDLETOWN:					
13702	Romanzo. Misura Esatta	Santo Cannota	5.00	1.4708	negative	negative	negative
13703	Carmelo. Carmelo Co., N. Y., Importers	C. Musalli	4.00	1.4705	negative	negative	negative
		NEW BRITAIN:					
13704	Superfine. F. Butolli, Lucca, Tuscany, Italy	S. Arata	5.00	1.4710	negative	negative	negative
13707	Termini Imerese. Sicilia, Italia	S. D. Cerbo	4.00	1.4707	negative	negative	negative
13705	Poletico	A. Mancini	4.60	1.4710	negative	negative	negative

TABLE VII. INSPECTION OF OLIVE OIL—*Continued.*

Number.	Brand.	Dealer.	Price per gal.	Refractive test Index @ 15.5	Halphen test for cottonseed oil.	Baudouin test for sesame oil.	Nitric Acid test for corn oil.
	Not Found Adulterated—Continued.	NEW HAVEN:					
9910†	Partenope. Imported. Puziello, Luccaro & Co., Brooklyn, N. Y.	Cash Grocery	$4.80	1.4712	negative	negative	negative
13463	Anita. United Pure Food Co., Importer	Michael Barbuto	4.00	1.4708	negative	negative	negative
13458	Italia. Filippe Bario, Lucca, Tuscany	G. Barera	4.00	1.4704	negative	negative	negative
13715	White Horse. J. S. Pride, Importer	Co-operative Trentino	5.00	1.4710	negative	negative	negative
13461	Domino. Extra Virgin. Virgine Internationala, Chicago	French-Italian Imp'ting Co	4.00	1.4708	negative	negative	negative
13462	Extra-Lucca. Italy. Packed for R. Martorelli	Marianna Gaetano	4.00	1.4708	negative	negative	negative
13459	E & T. Economon & Theodos, Importers, New York	Antonio Pepe	4.00	1.4710	negative	negative	negative
12973	Olio D'Puro	Real Co	......	1.4703	negative	negative	negative
14287	Pompeian. The Pompeian Co., Baltimore	John W. Scobie	......	1.4709	negative	negative	negative
		NEW LONDON:					
13720	Polctico Brand-La Mignore, Mariea Extra	A. Laverone	5.00	1.4707	negative	negative	negative
13721	Gloria. Gloria Olive Oil Co., Importers	A. D. Maggio	5.00	1.4707	negative	negative	negative
		NEW MILFORD:					
13711	Lalance. French oil	Kyoto Tea Co	4.40	1.4704	negative	negative	negative
13710	Carmelo. Carmelo Co., N. Y., Importers	G. B. Schiappacasse	5.00	1.4707	negative	negative	negative
13709	Rome	S. Vivierto	5.40	1.4704	negative	negative	negative

† Sampled by Station Agent.

TABLE VII. INSPECTION OF OLIVE OIL—*Continued.*

Number.	Brand.	Dealer.	Price per gal.	Refractive test Index @ 15.5	Halphen test for cottonseed oil.	Baudouin test for sesame oil.	Nitric Acid test for corn oil.
	Not Found Adulterated—Continued.						
		NOROTON:					
13495	The Lazeran. Nice, Paris & N. Y.	Richard Dugdale	$4.00	1.4702	negative	negative	negative
		NORWICH:					
13719	Soprafino Marca Toredor. Francesco Albano, N. Y.	Frank Ferry	5.00	1.4704	negative	negative	negative
		SEYMOUR:					
13476	Taygete. C. S. Calanopulus	A. Conkos	5.60	1.4700	negative	negative	negative
		SOUTH NORWALK:					
13487	Domico Extra. Internationala, Chicago.	Raffaelo Cocehia	5.00	1.4706	negative	negative	negative
		THOMPSONVILLE:					
13452	Elysee Palace. Elysee Olive Oil Co., New York	Antonio di Agostino	4.28	1.4705	negative	negative	negative
13450	White Horse. J. S. Prides, Importer	Carlo Peris	3.40	1.4708	negative	negative	negative
13451	Luida. Nice (France), Malaga (Spain)	Carlo Peris	3.30	1.4705	negative	negative	negative
		TORRINGTON:					
13479	Prodetti Italiano. W. P. Bernagozzi & Co.	S. Marbarek	4.40	1.4705	negative	negative	negative
		STAMFORD:					
13467	Makris. B. G. Makris, Importer	Arena Brothers	4.00	1.4705	negative	negative	negative
13473	E. & T. Economon & Theodos, Importers, N. Y.	R. Campanile	4.80	1.4707	negative	negative	negative
13466	Spanish. Avanzino Bros., Boston	Cascanna Bros	4.00	1.4708	negative	negative	negative
13468	Carmela. Nouvelles, Nice (France), Malaga (Spain)	G. Epifanio	5.40	1.4707	negative	negative	negative

TABLE VII. INSPECTION OF OLIVE OIL—*Continued.*

Number.	Brand.	Dealer.	Price per gal.	Refractive test Index @ 15.5	Halphen test for cottonseed oil.	Baudouin test for sesame oil.	Nitric Acid test for corn oil.
	Not Found Adulterated—Concluded.	WATERBURY:					
13480	Tuscany Supreme. Lucca, Italy, Frank Pepe, Importer	T. Marino	$4.00	1.4704	negative	negative	negative
13481	Stella d'Oro. Italy	Nicola Rosa	4.40	1.4706	negative	negative	negative
13482	Superfine Alba. Packed in Italy	Nicola Rosa	4.40	1.4706	negative	negative	negative
13483	Crisafulli. Lucca, Tuscany, Italy	Nick Scopette	4.80	1.4706	negative	negative	negative
		WESTVILLE:					
13457	Italy. Philip Bario & Co., Lucca, Tuscany	Mary Riccio	4.60	1.4704	negative	negative	negative
		WILLIMANTIC:					
13718	Pasco. Porte Morizio, Italia	Joseph Giraca	5.20	1.4704	negative	negative	negative
13717	Finest Quality Italian Lucca	W. H. Hibbard	4.00	1.4710	negative	negative	negative
		WINDSOR LOCKS:					
13517	Pasco. In bulk	Italian Co-operative Store	......	1.4705	negative	negative	negative
13518	Pompeian. In bulk	Italian Co-operative Store	......	1.4705	negative	negative	negative
13519	W. P. Bernagozzi. In bulk	Italian Co-operative Store	......	1.4705	negative	negative	negative
13520	Carmela. In bulk	Italian Co-operative Store	......	1.4705	negative	negative	negative
	Containing Cottonseed Oil but Legally Labelled.	MIDDLETOWN:					
13701	Termini Imerese. Cottonseed & Olive Oils. C. Battaglia, Sicilia, Italia	Antonio Marino	3.00	1.4746	positive	negative	negative
		NEW HAVEN:					
13722	Olio Finissimo (Cottonseed & Olive oils)	F. Beneventu	2.50	1.4742	positive	negative	negative
13723	Tripolitana. (Cottonseed & Olive oils)	A. Pepe	2.60	1.4739	positive	negative	negative

TABLE VII. INSPECTION OF OLIVE OIL—*Continued.*

Number.	Brand.	Dealer.	Price per gal.	Refractive test Index @ 15.5	Halphen test for cottonseed oil.	Baudouin test for sesame oil.	Nitric Acid test for corn oil.
	Adulterated or Misbranded—Containing Cottonseed Oil.						
		ANSONIA:					
13464	Termini Imerese	G. C. Artiglia	$4.00	1.4712	positive	negative	negative
		BRIDGEPORT:					
13471	Frate del Bosco Lucca. Tuscany, Italy	Thomas Arganis	4.60	1.4737	positive	negative	negative
13488	Extra fine Lucca. Garra & Trusso	Riozzoli & Brualdi	4.20	1.4732	positive	neagtive	negative
13469	Frate del Bosco Lucca Brand. Tuscany, Italy	Quatraella & Panucci	3.40	1.4737	positive	negative	negative
13113	Termini Imerese	Antonio Russo	......	1.4736	positive	negative	negative
13114	Tripolitania	Antonio Russo	......	1.4740	positive	negative	negative
13115	Puro D'Oliva, Lucca	Antonio Russo	......	1.4728	positive	negative	negative
13472	Termini Imerese. Sicily, Italy	Venicia Importing Co.	3.00	1.4742	positive	negative	negative
		DERBY:					
13477	Lucca	C. Cavallaro	4.60	1.4722	positive	negative	negative
13478	Purissimo di Bitonto Bari	Carmela Propolo	4.00	1.4724	positive	negative	negative
		HARTFORD:					
12971	Extra No. 1. Packed for Garra & Trusso, N. Y.	Benj. Feir	......	1.4718	positive	negative	negative
13118	In bulk	B. De Pasquale	......	1.4729	positive	negative	negative
13453	Crisifulli. Imported from Lucca, Tuscany	Frank Tinnerella	5.00	1.4718	positive	negative	negative
		MIDDLETOWN:					
13700	Bitonto-Bari	Concetto Russo	3.20	1.4722	positive	negative	negative

TABLE VII. INSPECTION OF OLIVE OIL—*Concluded.*

Number.	Brand.	Dealer.	Price per gal.	Refractive test Index @ 15.5	Halphen test for cottonseed oil.	Baudouin test for sesame oil.	Nitric Acid test for corn oil.
	Adulterated or Misbranded—Containing Cottonseed Oil—Concluded.						
		NEW BRITAIN:					
13706	Riviera. Cochram & Co., Distributors	C. Banini	$3.00	1.4735	positive	negative	negative
		NEW HAVEN:					
13460	Termini Imerese. Sicilia, Italia	Saggio Caleedonio	5.60	1.4738	positive	negative	negative
13714	Soprafino Italia. Lucca, Tuscany, Italy	Filipe Bros	4.00	1.4739	positive	negative	negative
13982	Pompeian*	P. Lucariello	......	1.4746	positive	negative	?
9909†	Olio Puro. Lucca, Italy	Grocery, 135 Wooster St.	3.80	1.4723	positive	negative	negative
13713	Olio Puro. Lucca, Italy	M. Marenna	4.00	1.4729	positive	negative	negative
13724	Tipo Termini Imerese. Sicilia, Italia	Leucio Rapuano	2.66	1.4742	positive	negative	negative
13716	Tripolitania. Cottonseed & Olive oil	Luigi Amatruda	4.00	1.4742	positive	negative	negative
		NORWALK:					
13486	Olio Puro. Lucca, Italy	James Nicholas	3.60	1.4739	positive	negative	negative
		WATERBURY:					
12972	Termini Imerese	S. Bellachino	......	1.4751	positive	negative	negative
13515	Unknown	Submitted by Dairy & Food Commissioner	......	1.4727	positive	negative	negative
	Adulterated or Misbranded—Containing Corn Oil.						
		NEW HAVEN:					
13712	Olio Puro. Lucca, Italy	Joe Guarini	3.00	1.4761	negative	negative	positive
		RIDGEGIELD:					
13708	Extra Fine. Lucca, Italy	Brunetti & Gasperini	2.66	1.4761	negative	negative	positive

* Refilled can. † Sampled by Station Agent.

Meissel numbers of 0.49 to 0.50. A sample of refined corn oil and one of crude corn oil[1] were examined in this laboratory and Reichert-Meissel figures of 1.49 and 2.69 respectively were obtained. Different methods of extracting the oil, differences in degree of refinement and in some cases a confusion of the terms used in expressing results explain the variations noted. It is evident that volatile fatty acids cannot be relied upon to distinguish corn oil from olive and cottonseed oils. The analyses of all the cooking fats examined appear in Table VIII.

TABLE VIII—ANALYSES OF COOKING FATS.

Number.	Brand.	Moisture.	Protein (N x 6.25).	Ash.	Fat.	Free fatty acids as Oleic.	Refractometer reading at 40°C	Reichert-Meissel No.	Halphen test.	Nitric Acid test.
		%	%	%	%	%				
8164	Wesson Oil	0.06	....	....	99.94	0.06	59.5	1.04	red	yellow
8165	Mazola....	0.00	....	....	100.00	0.17	62.5	0.86	yellow	red-brown
8166	Vegetole...	0.02	0.38	0.02	99.58	0.15	59.5	0.45	deep red	red-brown
8167	Cottolene..	0.02	0.31	0.08	99.59	0.10	56.0	0.48	deep red	red-brown
9583	Crisco.....	0.02	0.19	0.05	99.56	0.18	54.7	0.50	yellow	yellow
9584	Kuxit.....	0.31	0.13	0.03	99.53	0.15	37.0	5.03	yellow	yellow
9879	Sawtay....	0.03	0.38	trace	99.59	0.08	35.0	8.02	yellow	....

BUTTER.

The only numerical standard in the present definition of butter is that it shall contain not less than 82.5 per cent. of milk fat. The question of the revision of butter standards has been under discussion by Federal and State authorities and creamery men for the past year. For information in connection with this matter twelve samples of genuine butter, fairly representative of this product in the state, were taken by the Dairy and Food Commissioner and submitted to us for analysis.

The results appear in Table IX. All samples are seen to exceed 80 per cent. milk fat, and all but two exceed the present standard of 82.5 per cent.

[1] Both furnished by the Corn Products Refining Co., New York.

TABLE IX. ANALYSES OF GENUINE BUTTER.

Number.	Dealer.	Water.	Fat.	Casein.	Salt.	Undetermined.
		%	%	%	%	%
12400	L. F. Turner, Burlington	11.78	84.06	1.76	2.40	0.00
12401	Canton Creamery, Canton	12.61	85.75	1.35	0.21	0.08
12402	Morton & Dwyer, Manchester	8.52	88.59	1.60	1.27	0.02
12403	H. C. Tracy, Hartford	13.39	84.13	1.36	1.12	0.00
12404	Martin Stauss, Rockville	10.61	87.47	1.24	0.68	0.00
12405	Wm. Bemhauer Est., Rockville	12.63	81.36	1.83	4.05	0.13
12406	Oswald Saenger, Rockville	12.35	85.30	1.64	0.71	0.00
12471	R. B. Muller & Co., Hartford	12.07	83.99	2.21	1.73	0.00
12472	Boston Branch Grocery, Hartford	10.57	86.78	1.28	1.36	0.01
12473	Glaser & Englert, Rockville	14.79	83.20	1.34	0.64	0.03
12474	Glaser & Englert, Rockville	11.64	83.95	1.21	3.06	0.14
12475	H. J. Bingenheimer, Rockville	15.88	80.93	1.35	1.84	0.00

Fourteen other samples were submitted by the Commissioner for examination as to adulteration or misbranding. Eight were found to be genuine butter, and six were renovated.

One sample was submitted by Mrs. E. B. Sage, North Woodbury. It was found to be genuine butter.

OLEOMARGARINE.

There is no official definition or standard for oleomargarine in this state, except that the Statutes direct that it shall be "free from coloration and from any ingredient intended to cause it to look like butter." For this reason oleomargarine cannot be sold if it contains added artificial color. The use of naturally high colored fats in the manufacture of oleomargarines violates the above restriction in that the product obviously will not be free from coloration. It may be argued, however, that it is free from any ingredient *intended* to cause it to look like butter, which ultimately brings the matter up for a decision in court. It is to be regretted that the law does not provide, either that the product shall be white, or else permit the addition of harmless coloring matter, which privilege is accorded to butter.

Thirteen samples of oleomargarine were submitted by the Dairy and Food Commissioner.

No annatto or coal-tar dyes were found in any of the samples. In all cases where tests were made for carotin, positive results were obtained. Reichert-Meissel numbers determined in these cases indicated from 3 to 20 per cent. of butter in the product. Palmer and Eckles,[1] Gill[2] and others have shown that carotin is a color principle rather widely distributed in plants and in vegetable and animal oils and fats. It is present in butter fat, being derived from grass, and occurs also in palm oil. The detection of carotin, therefore, is without the diagnostic significance it was formerly supposed to have.

Analyses of five samples collected by this station, previously reported, appear in Table X.

NUT MARGARINE.

Nut margarines differ from oleomargarine in that they do not contain the fat of slaughtered animals. They are chiefly composed of cocoanut fat with admixtures of other vegetable fats or oils to give the proper consistency. Peanut or cottonseed oils are used for this purpose. The fats are ripened with milk to which a culture of lactic acid-forming bacteria has been added, in order to impart the flavor of butter. They are quite perishable products and manufacturers do not encourage jobbers to keep large quantities on hand, preferring to have them supplied with fresh material. Benzoate of soda is used as a preservative in some cases, which is legal provided the amount does not exceed 0.1 of one per cent. and is so stated. The color dispensed with nut margarines we have found to be annatto. Analyses of eight of these products, including three brands previously reported, are given in Table X.

Cereal Products, etc.

SUBSTITUTE FLOURS.

Flours other than wheat flours have been of especial interest to the housewife during the past year. From the standpoint of calorie yield any of the substitutes are the equal of wheat flour, but by reason of its superior baking qualities, due to the gluten it

[1] Jour. Biol. Chem. **17**, 190-249, 1914.
[2] Jour. Ind. & Eng. Chem., **9**, 136, 1917; **10**, 612, 1918.

TABLE X. ANALYSES OF MARGARINES.

Number.	Brand.	Moisture.	Protein (N x 6.25)	Ash.	Fat.	Free Fatty Acids, as Oleic.	Refractometer reading at 40°C.	Reichert-Meissel No.	Halphen test.	Nitric Acid test.
	Nut Margarine.	%	%	%	%	%				
8168	A 1. Downey Farrell Co., Chicago	10.84	1.25	4.51	83.40	0.45	40.0	7.00	deep pink	brown
8169	Cocoanut. Nucoa Butter Co., Soho Park, N. J.	6.53	0.69	1.58	91.20	0.39	37.2	7.50	yellow	brown
8170	Providence Churning Co., Prov., R. I.	11.28	0.75	1.14	86.83	0.47	39.0	6.15	yellow	yellow
9883	Nut-ola. Armour Co.	9.44	2.71	6.06	81.75	0.25	39.0	6.37	yellow	....
9898	Gem. Swift & Co.	12.64	1.36	2.91	83.09	0.95	40.0	6.69	pink	....
9911	Benefit. Sweet Nut Butter Co., Boston, Mass.	12.35	1.29	2.08	84.27	1.11	37.0	6.22	yellow	....
9937	Kingnut. Kellogg Products, Inc., Buffalo	10.12	1.87	3.00	85.01	0.19	38.5	6.50	yellow	....
9938	Nut Marigold. Marigold Margarine Fact. 5th Dist., N. J.	14.71	1.19	1.51	82.58	1.03	38.0	6.62	yellow	....
	Oleomargarine.									
8171	Lilly. Swift & Co.	1.67	0.56	0.41	97.36	0.74	52.0	1.50	deep red	red-brown
8172	Premium. Swift & Co.	2.54	0.63	0.60	96.23	0.63	49.2	0.99	red	red-brown
8173	Gilt Edge. John F. Jelke Co.	8.52	1.25	1.62	88.61	0.74	49.2	.....	pink	red-brown
8175	Silver Churn. Armour Co.	4.90	0.56	1.44	93.10	0.80	51.0	1.30	deep red	red-brown
9994	Good Luck. John F. Jelke Co.	9.20	1.00	3.08	86.72	0.50	49.3	.....	red	red-brown

contains, wheat has the advantage over the other cereals as a bread grain.

The analyses of sixteen flours derived from cereal grains and from potatoes, are given in Table XI.

BREAKFAST FOODS, HEALTH FOODS, ETC.

Four breakfast foods not hitherto analyzed in this laboratory have been examined.

8174. Whole grain wheat. Prepared ready to eat. Price 10 cents per can of 10 ounces, net weight. Made by the Whole Grain Wheat Co.

9597. Cream of Barley, American Barley Co., Minneapolis, Minn. Price 25 cents per package of 1 lb. 8 ozs.

9598. Cream of Rye. Minneapolis Cereal Co., Minneapolis, Minn. Price 20 cents per package of 1 lb. 2 ozs.

11291. Fancy Hominy Grits. The Quaker Oats Co., Chicago. Price 15 cents per package of 1 lb. 8 ozs.

Analyses are as follows:

No.	8174	9597	9598	11291
	%	%	%	%
Moisture	66.16	9.17	11.47	13.15
Ash	1.54	1.36	1.65	0.48
Protein	6.63	11.06	12.00	7.88
Fiber	1.15	0.59	1.43	0.20
Nitrogen-free extract	23.75	76.21	71.90	77.84
Fat	0.77	1.61	1.55	0.45
Starch	.....	62.38	46.01	70.99
Total sugar, as invert sugar	1.23	.....	.....	.....

Two products of the class of health foods and two miscellaneous preparations were also examined.

9874. Grant's Hygienic Crackers. For constipation, indigestion, dyspepsia and sour stomach. Hygienic Health Food Co., Inc., Berkeley and Oakland, Calif.

9875. Dr. Vons' Health Biscuit. Relieves constipation, strengthens stomach and bowels.

9872. Goodmans Berliner Tea. Matzoths. A. Goodman & Sons, Inc., New York.

Number.	Name of Flour.	Price per lb.	Moisture	Ash.	Protein.	Crude Fiber.	Nitrogen-free Extract.	Fat.	Starch.
	Barley Flour.	cents	%	%	%	%	%	%	%
9914	In bulk	9	11.11	1.75	12.75	0.84	71.13	2.42	55.29
9915	In bulk	9	11.40	1.51	12.38	1.06	71.21	2.44	56.42
9917	In bulk	8	11.60	1.60	11.75	1.35	71.45	2.25	55.29
	Corn Flour.								
9913	In bulk	8	11.22	1.34	9.00	0.85	74.34	3.25	64.74
9919	In bulk	8	12.67	1.01	7.63	0.38	76.16	2.15	68.91
9594 A	In bulk, yellow	......	12.01	0.68	7.75	0.44	77.47	1.65	70.20
9594 B	In bulk, white	......	11.76	0.82	9.69	0.51	75.96	1.26	59.63
11238	Maize,* in bulk	10	13.88	0.58	7.81	0.19	76.92	0.62	57.88
	Oat Flour.								
9595	Health Food Co., New York	......	10.28	1.84	15.06	0.75	65.70	6.37	54.79
	Potato Flour.								
9596	Potatine, Strohmer and Arpe Co., New York	......	14.90	0.28	0.63	none	84.16	0.03	81.17
9936	Potato starch, Stickney and Poor	12	15.87	0.64	0.63	none	82.84	0.02	81.22
9920	In bulk	18	17.03	0.38	0.25	none	82.32	0.02	79.68
9918	Austin, Nichols & Co., Inc., New York	22	16.19	0.34	0.63	none	82.81	0.03	80.27
	Rice Flour.								
9921	In bulk	14	12.22	0.99	7.38	0.09	78.52	0.80	72.67
9912	In bulk	13	11.64	0.87	7.19	0.19	79.58	0.53	74.92
9916	In bulk	14	11.80	0.52	7.19	0.16	79.83	0.50	74.53

*Flakes.

9871. Home Made Sun Rise Rice Cakes. Made from rice flour, wheat flour, eggs and sugar. The Sun Rise Rice Cake Co., New York.

Analyses of these products are as follows:

No.	**9874**	**9875**	**9872**	**9871**
	%	%	%	%
Moisture	9.16	9.34	9.11	2.51
Ash	3.21	4.05	0.61	0.37
Protein	12.25	9.75	14.19	6.88
Fiber	1.49	4.43	0.28	0.16
Nitrogen-free extract	71.94	66.30	75.50	89.78
Fat	1.95	6.13	0.31	0.30
Starch	52.99	22.78	64.07	36.79
Sugar	.....	.....	.....	39.54

Two samples, **12905**, Rye Meal, and **14154**, White Floured Corn Meal, were submitted by the Dairy and Food Commissioner. The rye meal was found to be genuine, apparently the ground whole rye. The corn meal was adulterated, in that it contained maggots and grain beetles.

Fruit Juices and Carbonated Beverages.

The sugar shortage of the past year has made it difficult for manufacturers of carbonated soft drinks to obtain suitable sweetening agents. The necessity for conserving sugar has suggested the use of the following substitutes for this purpose; *viz.*, corn syrup (glucose), corn sugar (crystalized glucose), maltose syrup, honey and high grade refiners' syrup. Skinner and Sale,[1] after a study of various formulas involving the use of these sweeteners with ordinary sugar, found that none of them could be used to replace all of the sugar, but that one-third to one-half of the amount ordinarily used could be satisfactorily replaced. The keeping qualities of such mixtures, while not so high as when cane sugar is used alone, was found to be satisfactory for limited periods of about six weeks. The relative sweetness of these substitutes as compared with ordinary cane sugar (sucrose), taken to be 100 is, honey 75; corn sugar 45; maltose syrup 30; corn syrup 20.

While there is no restriction on the use of the above named sweetening agents, their presence is required to be stated on the label whenever used.

[1] U. S. Dept. Agr. Bureau Chemistry.

Saccharin is not considered to be a legitimate sweetening material and its use in normal foods is prohibited by the Rules and Regulations of this State. Its use is illegal whether or not its presence is stated on the label.

The use of harmless colors, including ten colors of coal-tar origin, finds especial application in beverages of this class. Declaration of their use upon the label is, however, necessary to make the product legal.

There must also be on the label a declaration of the net contents.

In goods bottled locally we have noted considerable carelessness in the matter of labels. For example, the printed label may bear the name and amount of the product; a legend blown in the bottle may give the name of a different manufacturer and state a different net contents, while the patent cap on the bottle may declare the presence of artificial color and may or may not agree with the other two legends as regards the kind and amount of the product within the container.

The law recognizes but one label and all the required information must be contained thereon.[1] A statement of quantity of contents blown in the bottle is permissible if plain and conspicuous and in conformity in other respects with the regulations.[2]

In our opinion the patent cap on a bottle, easily interchanged, is not the place to look for reliable information regarding the contents of the bottle, and if the statement blown in the bottle conflicts with that of the printed label, the latter should be regarded as the true label.

Eleven fruit juices and thirty-seven carbonated beverages have been examined and the results tabulated in Table XII.

Sugars were determined as reducing sugar calculated as invert sugar, and as cane sugar calculated from the increase in reducing sugar after inverting at 69°C for 10 minutes, using the factor 0.95.

Total solids were obtained by drying to constant weight in vacuum at 70°C.

Of the forty-eight samples examined, forty bore a declaration of net contents which in twenty-eight cases was correct or within a reasonable degree of variation; *viz.*, one ounce for thirty-

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[1] Rules and Regulations Relating to the Food and Drug Law, Connecticut, Regulation 16.

[2] Rules and Regulations Relating to the Food and Drug Law, Connecticut. Par. c, p. 49.

TABLE XII. ANALYSES OF FRUIT JUICES AND CARBONATED BEVERAGES.

Number.	Description of Sample.	Price per bottle.	Volume of contents declared.	Volume of contents found.	Sugars. Reducing (as invert).	Sugars. Sucrose.	Total solids.	Saccharin.	Preservative.	Color.
	Grape Juice.	cents.	ozs.	ozs.	%	%	%			
9888	Sunbeam. Austin, Nichols & Co., Inc., New York	19	16.0	.....	15.20	0.29	17.17	none	none	natural
11225	Dover Bay. Cleveland Fruit Juice Co., Cleveland, O.	18	4.0	.....	13.57	0.00	15.98	none	none	natural
9895	Blue Seal. Lewis DeCroff & Son, New York	15	8.0	.....	16.37	1.52	18.93	none	none	natural
9887	Fremont. Fremont Grape Juice Co., Fremont, Ohio	19	16.0	.....	15.05	0.44	17.75	none	none	natural
9930	Fremont. Fremont Grape Juice Co., Fremont, Ohio	10	6.0	6.0	14.34	0.14	15.89	none	none	natural
9894	Red Wing. Puritan Food Products Co., Fredonia, N. Y.	15	4.0	.....	16.62	0.09	20.39	none	none	natural
9880	Red Wing. Puritan Food Products Co., Fredonia, N. Y.	25	16.0	16.0	16.95	0.05	18.45	none	none	natural
9886	Gold Medal. Randall Grape Juice Co., Ripley, N. Y.	10	6.0	6.0	16.86	0.32	18.84	none	none	natural
9881	Epicure. John Sills & Sons, New York	21	16.0	16.0	17.63	0.11	19.06	none	none	natural
	Loganberry Juice.									
9995	Jones Bros. & Co., Portland and Newberg, Oregon	25	16.0	15.3	14.25		14.81	....	none	natural
9923	Phez.* Pheasant Fruit Juice Co., Salem, Oregon	25	8.0	7.6	26.89	3.98	32.73	none	none	natural

* Add two parts of water before serving.

TABLE XII. ANALYSES OF FRUIT JUICES AND CARBONATED BEVERAGES.—*Continued.*

Number.	Description of Sample.	Price per bottle.	Volume of contents declared.	Volume of contents found.	Sugars. Reducing (as invert).	Sugars. Sucrose.	Total solids.	Saccharin.	Preservative.	Color.
	Carbonated Beverages.	cents.	ozs.	ozs.	%	%	%			
11232	Cream Soda.** West End Bottling Co., Bridgeport	12	24.0	24.0	7.38	0.80	8.27	none	none	caramel[1]
11226	Cream soda. Kenney & Ross, Bridgeport	13	25.0	22.0	5.61	0.29	5.86	present	none	amaranth & veg.[2]
9943	Vani cream. Yolens, Dranoff & Co., New Haven	12	.....	33.0	1.44	1.86	3.64	present	none	none found[1]
9939	Cream soda.† John Clancy, New Haven	13	28.0	28.0	2.26	0.66	3.05	present	none	colorless
9925	Cream soda.** Star Bottling Co., New Haven	15	27.0	27.0	7.98	0.05	8.46	none	none	none found
9891	Cream soda. Shanbrom's Bottl'g Wks., New Haven	12	.....	30.0	2.44	4.28	6.92	none	none	none found[1]
9885	Ginger soda. Bacon Bottl'g. Wks., Hartford	12	.....	25.0	4.68	3.63	8.76	none	none	caramel[1]
9926	Ginger ale. Francis H. Leggett & Co., New York	12	16.0	16.0	8.71	0.19	9.09	none	none	none found
9922	Ginger ale. Clysmic Spring Co., Ellenville, N. Y	15	15.5	15.7	8.10	1.97	10.28	none	none	none found
11224	Grape smash. Tropical Fruit Juice Co., Chicago	5	6.5	.....	11.69	0.49	12.37	none	none	amaranth[1]
11227	Grape soda. Kenney & Ross, Bridgeport	13	25.0	21.0	6.79	0.15	7.33	present	present[3]	amaranth[1]
11236	Lemon soda. Greater N. Y. Bottl'g. Co., Bridgeport	5	8.0	8.7	4.55	1.05	5.90	present	none	colorless
11231	Lemon soda. Kaplan Bros., Bridgeport	12	24.0	24.0	6.06	3.52	9.50	none	none	colorless

** Artificial. † Compound. [1] Artificial color declared. [2] Artificial color not declared.
[3] 1/10 of 1 per cent. benzoate of soda declared; .03 per cent. found.

TABLE XII. ANALYSES OF FRUIT JUICES AND CARBONATED BEVERAGES.—*Continued.*

Number.	Description of Sample.	Price per bottle.	Volume of contents declared.	Volume of contents found.	Sugars. Reducing (as invert).	Sugars. Sucrose.	Total solids.	Saccharin.	Preservative.	Color.
	Carbonated Beverages, continued.	cents.	ozs.	ozs.	%	%	%			
11228	Lemon soda. Kenney & Ross, Bridgeport.	13	24.0	21.0	5.95	0.75	6.97	none	none	colorless
9942	Lemon soda. Yolens, Dranoff & Co., New Haven	12	.....	30.0	2.81	0.40	3.20	present	none	none found[1]
9941	Lemon soda. Clancy Bottl'g Wks., New Haven	13	24.0	28.5	4.87	0.24	6.26	none	none	colorless
9884	Lemon soda. The Bacon Bottl'g Wks., Hartford	12	.....	22.7	4.09	4.79	9.45	none	none	colorless[1]
9892	Lemon soda. Shanbrom's Bottl'g Wks., New Haven	12	.....	36.6	3.11	3.10	6.66	none	none	colorless
11237	Orangeade. Greater N. Y. Bottl'g Co., Bridgeport	5	6.0	8.7	5.07	2.51	7.80	none	none	orange I[1]
11233	Orange soda.** West End Bottl'g Co., Bridgeport	12	24.0	24.2	5.84	1.83	7.73	none	none	orange I[1]
11230	Orange soda. Kaplan Bros., Bridgeport	12	24.0	25.0	4.66	2.01	7.02	none	none	orange I[2]
9929	Orange Whistle. Orange Whistle Co., St. Louis	7	6.5	6.5	5.49	4.62	10.32	none	present[5]	unindentified[2, 4]
9933	Orange soda. Bottler unknown	12	.....	28.0	3.96	1.85	5.99	none	none	amar'th, orange I[1]
9931	Orange soda. Star Bottl'g & Supply Co., New Haven	17	28.0	28.3	5.89	1.82	7.87	none	none	orange I[2]
9890	Rexo Cola. The R. G. Lyons Co., New York	5	6.0	6.9	10.60	0.25	10.95	none	none	caramel[1]
11234	Root Beer.** West End Bottl'g Co., Bridgeport	12	24.0	23.0	3.27	5.64	9.35	none	none	caramel[1]

** Artificial, [1] Artificial color declared. [2] Artificial color not declared. [4] Probably orange I.
[5] Less than 1/10 per cent. benzoate of soda declared; .03 per cent. found.

Number.	Description of Sample.	Price per bottle.	Volume of contents declared.	Volume of contents found.	Sugars. Reducing (as invert).	Sugars. Sucrose.	Total solids.	Saccharin.	Preservative.	Color.
	Carbonated Beverages, concluded.	cents.	ozs.	ozs.	%	%	%			
9944	Root Beer. Yolens, Dranoff & Co., New Haven	12	26.0	25.0	2.17	3.42	5.84	present	none	amaranth[2]
9932	Root Beer. Shanbrom's Bottling Wks., New Haven	12	28.0	27.7	8.18	0.14	8.71	none	none	caramel[2]
9928	Root Beer. Star Bottling & Supply Co., New Haven	15	28.0	28.2	1.32	5.27	7.34	none	none	caramel[2]
9927	Sarsaparilla. Star Bottling & Supply Co., New Haven	15	28.0	27.6	4.00	2.59	6.66	none	none	caramel[2]
9896	Sarsaparilla. Clancy Bottling Wks., New Haven	13	24.0	27.3	2.39	3.85	6.77	suspicious	none	caramel[1]
11235	Strawberry soda, Imitation. Greater N. Y. Bot. Co., Bridgeport	5	8.0	9.2	4.70	1.62	6.44	present	none	amaranth[1]
11229	Strawberry soda. Kaplan Bros., Bridgeport	12	24.0	25.0	5.27	3.10	8.56	none	none	amaranth[2]
9945	Strawberry soda. Yolens Min'l. Bottl'g. Wks., New Haven	12	26.0	26.3	1.01	3.33	4.32	present	none	amaranth[2]
9940	Strawbery soda. Clancy Bottl'g. Wks., New Haven	13	24.0	31.3	4.97	0.52	5.49	none	none	amaranth[1]
9934	Strawberry soda. Shanbrom's Bottl'g. Wks., New Haven	12	.....	32.8	5.39	0.10	5.69	none	none	amaranth[1]
9924	Strawberry soda. Star Bottl'g. Co., Inc., New Haven	15	28.0	26.2	6.61	2.00	8.59	none	none	amaranth[2]

[1] Artificial color declared. [2] Artificial color not declared.

two ounces, and one-half ounce for sixteen ounces above or below. In five cases the variations were deficiencies, and in seven they were overruns.

Saccharin was found in nine samples and one more was suspicious but tests were inconclusive.

No unpermitted colors were identified, but in eleven samples artificial colors were found when their presence was not declared. Four samples carried a declaration of color but none was found, the solutions being in some cases colorless.

No preservative was found except where declared and in those the amounts did not exceed the declarations.

Dried Eggs and Egg Substitutes.

Three samples of genuine dehydrated eggs have been examined, as follows:

No.	9991	9992	10327
	%	%	%
Moisture	4.44	3.68	6.13
Protein	38.13	42.50	39.13
Ash	4.06	4.17	3.83
Fat	44.68	41.72	44.69
Preservative	none	none	none

From these analyses it is seen that the essential food constituents of eggs are protein and fat.

During the past year numerous so-called egg substitutes have appeared on the market. While some of these specify that they are to be used for cooking only, they are, nevertheless, offered for use where eggs are called for in cooking or baking recipes.

Analyses show that these products consist essentially of protein, derived usually from casein or dried skim-milk powder, starch, and baking powder ingredients to supply the necessary leavening power. The chief suggestion of eggs lies in the artificial yellow color which they contain. They do not resemble eggs in substance or quality. They belong more properly to the class of self-raising flours.

Many states have passed stringent regulations with respect to this class of products, forbidding the use of the word egg on the label, except under specified conditions, and prohibiting in most cases the use of any artificial color.

Recently adopted regulations[1] in this State regarding these materials are as follows:

1. "Powdered Egg" or "Egg Powder" is held to mean only powdered, dessicated or dried eggs, exclusive of the shell.

2. "Egg Substitute Powder" is held to mean an article reasonably equivalent in substance and quality to whole egg material.

3. Any article which purports to replace wholly or in part whole egg material, whether for baking or other purposes, is held to be an egg substitute.

4. Egg substitutes are held to be Food Compounds or Imitations and are subject to Regulations already obtaining for such articles. (Regulations, 17, 20 and 21): further providing that (a) they shall bear a distinctive name; (b) the word *egg* shall form neither the whole nor any part of such name, nor shall the label bear any design or device suggesting eggs or egg material unless whole egg material comprises a preponderating part of the article; (c) the use of artificial color in any egg substitute not conforming to Paragraph 2 of this Regulation is held to be an adulteration.

Four products of this class have been examined:

9897. Ecc-O-Gene. Stated to be made from corn and milk products with certified pure food color.

12763. Yelco. Stated to contain powdered milk, rice flour, bicarbonate of soda, cream of tartar, tartaric acid, powdered tumeric and corn starch.

11469. Centenegg. Stated to contain vegetable, cereal and milk products and to contain no egg.

10651. Egg-Nu. Stated to contain the nutriment of eggs artificially colored.

The analyses are as follows:

No.	**9897**	**12763**	**11469**	**10651**
	%	%	%	%
Moisture	11.44	8.26	11.79	6.20
Ash	2.80	19.67	2.07	9.85
Protein	27.38	4.38	22.19	27.69
Fiber	.....	.....	0.08	trace
Nitrogen-free extract	57.51	65.55	63.77	50.61
Fat	0.87	2.14	0.10	5.65
Starch	49.33	41.62	56.36	23.65
Lecithin P_2O_5	0.01	0.005	.....	0.17
Color	Artif.[2]	Artif.[3]	Natural.	Artif.[4]

[1] Rules and Regulations Relating to the Food and Drug Law, Connecticut, October 1, 1918.

[2] Orange I. [3] Tumeric. [4] Orange I and Tartrazine.

None of these products complies with the new regulations in all respects. Egg-Nu may contain a small amount of egg material judging from the lecithin phosphoric acid content.

MILK.

No systematic inspection of market milk has been made by this station of its own initiative in recent years. The reason for this is that much of such work is done each year indirectly by the examination of samples taken by the Dairy and Food Commissioner, who receives and investigates complaints from local health officers and others regarding milk, and through whom prosecutions for violation of the laws governing the sale of milk are instituted. The percentage of adulteration found in this way cannot be taken as fairly representing the condition of the milk supply in this state, as practically all samples are taken upon complaint or suspicion.

The greater vigilance of health and other officials during the past year in the matter of milk supply is evidenced by the unusually large number of samples which we have been called upon to examine. This attention is abundantly justified. No single article of food is of such vital importance to the consumer as milk. There is no substitute for it, and it is essential that the supply be maintained both as regards quantity and quality.

Fourteen hundred and thirty-nine samples have been submitted to us by the Dairy and Food Commissioner. Of these seven hundred and sixty-four were not found adulterated. Four hundred and six were below the legal state standard. One hundred and seventy-one were diluted with water. Ninety were skimmed. Eight were both watered and skimmed.

In tabular form the results are as follows:

Not found adulterated	764	53.1%
Adulterated by dilution with water	171	11.8
Adulterated by skimming	90	6.3
Adulterated by dilution with water and skimming	8	0.6
Adulterated by reason of being below standard,		
in solids and solids not fat	177	12.3
in fat, solids and solids not fat	229	15.9
	1,439	100.0

It appears that about 12 per cent. of all samples examined were diluted with water. This offense is two-fold in character; the quality of the product is necessarily lowered, and its cleanliness may be seriously jeopardized. No matter how high the grade of milk may be from the standpoint of food ingredients as shown by analysis, if it is unclean it is dangerous. All efforts to free milk from animal dirt and protect it from contamination at the place of production and in transit are completely nullified by the addition of water which may contain the germs of disease.

Six and one-half per cent. of samples were skimmed. The majority of these was obtained from lunch counters where the dipping of milk is practiced. Milk fat rapidly rises to the top of the container where it may be removed, inadvertently perhaps in some cases, through insufficient mixing before portions are served.

Nearly thirty per cent. of the samples were below the required composition as set forth in the state law, which defines that milk of standard quality shall contain not less than eleven and three-quarters per cent. of milk solids, not less than eight and one-half of solids not fat, and not less than three and one-quarter per cent. of milk fats. These numerical standards do not describe a milk of exceptional excellence, but rather one of average or fair quality only. It is difficult to establish a standard for milk, which shall be satisfactory in all respects. The standard in this state corresponds to the Federal standard. White and Judkins[1] have studied the relation between fat and solids not fat in milk from various breeds of cows, and also present data as compiled by other investigators. In their opinion, which is based upon figures obtained, the present standard for solid not fat; *viz.*, 8.5 per cent., is too high. This is in accord with the experience of this laboratory, and it has been our practice in the inspection of milk not to class as adulterated such samples as are deficient in solids not fat alone.

From the data available on this point it is evident that for a given percentage of fat there is a corresponding range in percentage of solids not fat, and that as the fat increases the average of solids not fat increases also. It follows then that for a given fat content the required solids not fat should be correlated thereto. According to data as compiled by Lythgoe, Brown and Ekroth,

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[1] Storrs Agr. Exp. Sta. Bull. 94, Jan., 1918.

and White and Judkins, milk of 3.25 per cent. fat will contain on an average 8.3 per cent. solids not fat, the range being from 8.05 to 8.65 per cent. The same data show that a figure of 8.5 per cent. solids not fat is more properly correlated with 3.5 per cent. of fat.

The present standard of 3.25 per cent. of fat should not, in our opinion, be lowered. Milk testing below this figure is more often the result of improper mixing of the product of the herd than of actual fat deficiency. The latter opinion is shared by White and Judkins who show that the mixed milk of a herd comprised by Jerseys, Guernseys, Ayrshires and Holsteins did not fall below 3.88 per cent. in fat at any time during the period of one year, and who doubt if the fat standard should be lowered.

Analyses of two hundred and seventy-two samples of milks adulterated by dilution with water, skimming, or both, are given in Table XIII. Analyses of four hundred and six samples found to be below standard are not tabulated. Of this number two hundred and twenty-nine, or 56 per cent., exceeded 3.25 per cent. of fat but were below standard in solids and solids not fat. One hundred and seventy-seven were below in all respects.

Upon affidavits furnished by this laboratory the Dairy and Food Commissioner has held three hundred and thirty-four hearings on the subject of adulterated milk and has prosecuted one hundred and fifty-three cases.

Forty samples of milk were submitted by individuals for partial or complete analyses. Seven were found to be diluted with water, one was skimmed, nine were below standard, and twenty-three were passed.

Cream.

Eleven samples of cream were submitted for determinations of butterfat. Six of these were sent by the Dairy and Food Commissioner, for the purpose of checking candidates for a state license to test milk and cream.

Food Products Examined for Saccharin.

Four samples of Apple Sauce, two of Cranberry Sauce, one of Strawberry Syrup, fifteen of Apple Pie, thirteen of Prune Pie, and one of Squash Pie were submitted by the Dairy and Food Commissioner, to be examined for saccharin. It was found in

TABLE XIII. ADULTERATED MILK.

No.	Dealer.	Solids.	Fat.	No.	Dealer.	Solids.	Fat.
	Containing Added Water.				*Containing Added Water—continued.*		
	AVON.				BROOKFIELD—*con't.*		
12750	F. B. Woodford.....	11.21	3.5	14187	Steve Piskura.......	9.78	3.3
12751	F. B. Woodford.....	10.69	3.3	14197	Alex Tubursky......	9.91	3.4
				14191	F. Sherwood........	10.66	3.3
	BRANFORD.						
13219	John Tambaini......	9.65	3.0				
					BROOKLYN.		
	BRIDGEPORT.			13800	J. Molione..........	11.05	3.5
13227	Evergreen Dairy....	10.80	3.0	13801	J. Molione..........	9.97	2.6
13228	Evergreen Dairy....	10.59	3.0	13802	J. Molione..........	10.70	3.0
14013	Evergreen Dairy....	10.49	3.2	13803	J. Molione..........	10.23	3.1
14014	Evergreen Dairy....	10.62	3.3	13689	Albert Webb........	10.49	3.2
14015	Evergreen Dairy....	11.03	3.3	13691	Albert Webb........	11.16	3.4
14016	Evergreen Dairy....	10.60	3.1	13692	Albert Webb........	10.66	3.3
14077	Farmers Dairy Co...	10.35	3.0	13695	Albert Webb........	11.31	3.6
14078	Farmers Dairy Co...	11.19	3.4				
14079	Farmers Dairy Co...	10.80	3.1		CORNWALL.		
14080	Farmers Dairy Co...	11.19	3.4	13070	Benj. Cohen........	11.21	3.5
14081	Farmers Dairy Co...	9.93	2.9	13071	Benj. Cohen........	10.72	3.2
14282	Herbert's Star Dairy.	9.79	3.2	13072	E. Siminosky.......	10.60	3.0
14283	Herbert's Star Dairy.	10.59	3.2				
14284	Herbert's Star Dairy.	10.44	3.2		DANBURY.		
14285	Herbert's Star Dairy.	10.32	3.2	14235	Martin Repko......	11.45	4.0
14286	Herbert's Star Dairy.	10.17	3.2				
12865	Garden Restaurant..	9.66	2.8		DURHAM.		
14090	W. P. Hough Rest'nt.	10.79	3.2	13164	G. H. Bailey........	10.25	3.1
12856	Leong Sun Rest'nt...	9.19	2.3	13165	G. H. Bailey........	10.48	3.4
14091	Star Restaurant.....	9.78	2.9	13166	G. H. Bailey........	8.83	2.6
10	William Schatz......	9.79	3.0				
12296	William Schatz......	10.21	3.1		EAST HARTFORD.		
12297	William Schatz......	11.36	3.6	12435	M. H. Kearns.......	10.60	3.1
12299	William Schatz......	9.41	2.9	12436	M. H. Kearns.......	10.98	3.6
12858	M. Snow...........	9.56	3.4				
13221	Martin Snow.......	11.03	3.4		FAIRFIELD.		
				14010	Edwin M. Hill......	9.95	3.1
	BROOKFIELD				GAYLORDSVILLE.		
14198	Edward Beers.......	10.81	3.3	12517	John Cornwall......	11.02	3.4
14199	Edward Beers.......	10.82	3.2				
14200	Edward Beers.......	10.29	3.2		GOSHEN.		
14167	C. D. Bristol........	11.40	3.8	12260	Harrison Ives.......	10.33	3.0
14195	Peter Fennell.......	9.79	2.8	12261	Harrison Ives.......	11.38	3.9
14190	Frederick Gustafson.	12.14	4.4	12262	Harrison Ives.......	11.77	4.2
14212	Richard Harris......	8.80	2.6	12263	Harrison Ives.......	10.67	3.5
14185	Paul Kominack.....	10.02	3.2				
14186	A. Kominack.......	9.90	3.0		GRANBY.		
14196	Roy Montrose......	10.04	3.1	12719	A. B. Phelps........	11.41	3.6
14160	William Pechaski....	11.36	3.7	12720	A. B. Phelps........	10.70	3.1
14181	John Piskura.......	11.13	3.7	12721	A. B. Phelps........	11.78	4.1

TABLE XIII. ADULTERATED MILK—*Continued.*

No.	Dealer.	Solids.	Fat.
	Containing Added Water—cont'd.		
	GROTON.		
13405	Mrs. Francis Frank. .	10.70	3.5
13404	P. Vincent & Co. . . .	11.25	3.7
	GUILFORD.		
14005	Eber Fisher.	9.76	2.8
14008	Eber Fisher.	11.47	4.1
14009	Eber Fisher.	11.48	3.7
	HAWLEYVILLE.		
14251	Mike Melycher.	11.35	3.7
	MIDDLEFIELD.		
12250	Sidney J. Harvey. . . .	6.44	2.4
12251	Sidney J. Harvey. . . .	7.65	3.0
	MONROE.		
12939	Morris French	10.58	3.1
13244	Louis Snow.	10.21	3.0
13245	Louis Snow.	10.50	3.1
	MOOSUP		
12967	A. P. Cory.	9.07	2.6
12968	A. P. Cory.	8.97	2.6
12969	A. P. Cory.	9.58	3.0
	NEW BRITAIN.		
12955	Arcade Lunch.	10.82	3.1
12386	J. Battaglia.	8.30	2.6
12954	D. Cherniak	9.60	3.1
	NEW LONDON.		
13133	Geo. M. Chapin.	11.26	3.6
12433	V. Fields	7.75	2.4
	NEWTOWN.		
14038	Albert M. Boyson . . .	11.42	3.8
14043	Wm. Leibold.	10.01	2.8
14048	Adolph Urban.	11.08	3.5
14049	Adolph Urban	11.59	4.2
101	F. A. Young.	10.91	3.3
	NORTH BRANFORD.		
12626	Isaac Segel.	10.44	3.2
12627	Isaac Segel.	10.21	3.4
12628	Isaac Segel.	9.29	2.7
12629	Isaac Segel.	10.71	3.2
12630	Isaac Segel.	9.00	2.8
13267	Benj. Snider.	10.82	3.6
	Containing Added Water—cont'd.		
	NORTH WINDHAM.		
13848	F. W. Mueller.	10.00	3.[illegible]
13849	F. W. Muller.	9.65	2.[illegible]
13950	F. W. Muller.	12.31	5.[illegible]
13951	F. W. Muller.	9.78	3.[illegible]
	NORWICH.		
12345	Edward Holden	11.48	4.[illegible]
12346	Edward Holden	10.39	3.[illegible]
12347	Edward Holden	11.21	3.[illegible]
12348	Edward Holden	10.69	3.[illegible]
12349	Edward Holden	10.67	3.[illegible]
12450	Edward Holden	10.14	3.[illegible]
	PUTNAM.		
13106	Z. Paquin.	10.45	3.[illegible]
13107	Z. Paquin.	10.91	3.[illegible]
13108	Z. Paquin.	10.52	3.[illegible]
13109	Z. Paquin.	10.79	3.[illegible]
	ROCKY HILL.		
13839	Simon Cinni.	8.43	2.[illegible]
13840	Simon Cinni.	10.23	3.[illegible]
13837	A. & J. Mayerinvitch	11.60	3.7
	ROCKVILLE.		
12326	Henry Martin.	11.78	4.2
	SHARON.		
12956	Amile Envard.	11.03	3.3
	SHELTON.		
13170	Alfred Shaw	10.43	3.0
	SOUTHBURY.		
106	Henry Johnson.	10.15	2.6
	SOUTH KENT.		
12519	Mont Darling.	10.54	3.2
12521	Mont Darling.	10.62	2.8
	SOUTH MANCHESTER.		
13329	C. Hagnaw	9.41	3.3
13330	C. Hagnaw	9.39	3.3
13331	C. Hagnaw	9.41	3.3
13332	C. Hagnaw	9.39	3.3
13333	C. Hagnaw	9.45	3.3

TABLE XIII. ADULTERATED MILK—*Continued.*

No.	Dealer.	Solids.	Fat.
	Containing Added Water—cont'd.		
	STAFFORD SPRINGS.		
13447	Steve Dezso........	11.13	3.6
13449	Steve Dezso........	11.26	3.5
	STAMFORD.		
13041	Eagle Lunch........	10.65	3.1
13042	Hartford Lunch.....	10.72	3.2
13048	Quick Lunch........	10.24	2.8
	STEPNEY.		
13232	Louis Snow.........	10.54	3.3
13260	Louis Snow.........	10.64	3.4
	STORRS.		
12307	A. Kivoitzsky.......	11.56	3.8
	TRUMBULL.		
13250	Wolf Bernstein......	10.05	2.9
13251	Wolf Bernstein......	9.71	2.9
13252	Wolf Bernstein......	9.50	2.7
13253	Wolf Bernstein......	9.72	3.0
13254	Wolf Bernstein......	10.22	3.1
13255	Wolf Bernstein......	10.20	3.1
14082	Bernard Berske.....	9.83	2.3
13235	Geo. Bumbera......	9.62	2.9
13236	Geo. Bumbera......	10.08	3.1
13290	Burt Bros..........	7.68	2.5
13291	Burt Bros..........	9.63	3.6
14088	D. M. Fuller........	11.19	3.4
14068	Paul Goldstein......	10.37	2.7
14059	A. J. Moore.........	8.82	2.6
14060	A. J. Moore.........	9.27	2.7
13022	Leonard Palueko....	10.67	3.1
13023	Leonard Palueko....	11.52	3.8
13026	Francis Strobel......	10.20	3.0
14057	Hattie Wells........	10.00	3.6
14058	Hattie Wells........	9.66	3.3
	WATERBURY.		
13188	Belmont Lunch.....	10.72	3.2
	WATERFORD.		
13351	D. W. Barnes.......	10.65	3.2
13355	M. T. Beckwith.....	12.37	4.8
13363	Chas. Chapone......	11.03	3.5
13366	Chas. Chapone......	10.49	3.2
13381	Mrs. A. W. Wicks...	12.37	4.4

No.	Dealer.	Solids.	Fat.
	Containing Added Water—concluded		
	WESTPORT.		
13037	Wagner's Lunch.....	11.93	4.5
	WETHERSFIELD.		
13438	Andrew Olsen.......	10.20	3.2
13439	Andrew Olsen.......	10.51	3.3
13440	Andrew Olsen.......	10.51	3.4
13441	Andrew Olsen.......	9.80	2.7
	NO ADDRESS.		
13650	Steve Dezso........	11.00	3.6
12448	Andrew Furlong.....	10.99	3.3
13272	Geo. W. McCall.....	11.08	3.6
13092	Theo. Rachele......	11.10	3.5
	Skimmed Milk.		
	ANSONIA.		
13203	Puritan Lunch......	11.26	2.5
	BERLIN.		
12805	Salvador Gianfrito...	9.38	1.4
	BRIDGEPORT.		
12870	W. C. Ducharme....	10.42	2.1
12855	Essex Restaurant....	10.07	1.7
12904	(Sent by Board of Health)..........	9.91	1.6
	BROOKFIELD.		
14182	John Piskura.......	10.59	2.1
	CORNWALL.		
13073	J. Malasky.........	10.43	2.4
	DERBY.		
13208	Colwell Lunch......	11.22	2.7
13207	The Y. Lunch.......	9.52	1.7
	DURHAM.		
12252	Morris Walerstein...	10.88	2.1
	GREENWICH.		
13016	Lens Lunch.........	9.39	1.3
13017	Palace Lunch.......	9.11	0.8
13018	Whalen Lunch.....	9.07	1.1
13020	Klump's Restaurant..	10.47	2.1
13019	Koopman Rest'n....	8.90	0.6

TABLE XIII. ADULTERATED MILK—*Continued.*

No.	Dealer.	Solids	Fat.
	Skimmed Milk–cont'd.		
	GROTON.		
13402	Frank Bergman.....	9.13	1.4
12461	I. E. Crouch........	12.66	3.2
	HAMDEN.		
13078	Jacob Zabilowski....	10.21	2.4
	HARTFORD.		
12484	Auto Lunch........	11.91	3.1
12492	Majestic Lunch.....	11.74	2.5
12479	Schuman Lunch.....	11.77	2.4
12485	Hong Kong Rest'nt..	10.36	1.5
12487	Wiener Cafe & Res'nt	10.00	1.3
12491	John B. Ryan.......	11.74	3.0
	HEBRON.		
12443	M. W. Hills........	10.95	2.7
	MERIDEN.		
12800	J. S. Billings........	10.40	2.1
12394	W. E. Dyer.........	12.42	3.3
12801	F. M. Raymond.....	10.37	2.1
	MONROE.		
12938	Chester Terrell......	10.20	2.0
	MOOSUP.		
12970	L. C. Parker........	10.29	1.7
	NEW BRITAIN.		
12389	Mrs. Walter Lawson.	10.86	2.3
12385	Maxwell & Hills.....	10.26	1.8
12388	John Pethis.........	10.02	1.6
12392	E. A. Simpson......	11.22	2.5
	NEW HAVEN.		
12886	Boston Chop House No. 1............	10.99	2.1
12884	Boston Chop House No. 2............	10.40	1.3
12888	Home Lunch.........	10.81	2.3
12880	Olympia Lunch.....	10.23	2.0
12648	The Rail Lunch.....	10.90	2.4
12885	Brown's Restaurant..	11.17	2.6
	NEW LONDON.		
13373	F. E. G. Douglas....	11.25	2.4
13346	New London Candy Kitchen..........	12.18	3.0
13343	New London Lunch..	11.14	2.6
	Skimmed Milk–cont'd.		
	NEW LONDON–*cont'd.*		
13301	Paquette & LeBlanc.	9.87	2.2
13302	Paquette & LeBlanc.	11.00	2.5
13344	Swanson's Rest'nt...	9.87	1.1
13362	Lee Co.............	10.06	1.7
	NORWALK.		
13008	McCarthy Rest'nt...	10 41	1.9
	NORWICH.		
12424	Chamberlain & Co...	10.67	2.1
13966	Edward Holden.....	11.41	2.9
12423	N. Kontanis........	11.76	3.0
12428	Miss Isabell Murphy.	10.04	1.8
13925	J. G. Potter & Sons..	11.20	2.4
12426	Vellis Bros..........	11.27	2.4
	PUTNAM.		
13907	M. Paquin..........	11.26	2.8
	ROCKY HILL.		
13838	A. & J. Mayervitch..	10.50	2.0
	ROCKVILLE.		
13680	City Lunch.........	11.80	3.0
	SOUTH COVENRTY.		
12322	C. R. Knight.......	10.91	2.4
	SOUTH MANCHESTER.		
12314	Thomas Graham....	11.21	2.4
12316	Thomas Graham....	11.45	2.8
12317	Thomas Graham....	12.27	3.0
	SOUTH NORWALK.		
13004	Hartford Lunch.....	9.87	1.5
13003	Trip's Lunch........	10.85	2.5
13002	Middlebrook Rest'nt.	10.16	1.9
	STAMFORD.		
13043	Canthas Lunch......	10.27	2.1
13040	Royal Lunch........	9.44	1.8
13046	Wilt's Restaurant....	10.57	2.2
	SUFFIELD.		
12990	W. F. Cronan.......	10.77	2.2
	THOMPSON.		
12837	H. C. Reynolds.....	10.87	2.6

TABLE XIII. ADULTERATED MILK—*Concluded.*

No.	Dealer.	Solids.	Fat.
	Skimmed Milk–cont'd.		
	TRUMBULL.		
3233	Geo. Hoyt..........	11.29	2.7
	VERNON.		
2414	Jacob Kahn........	13.03	3.4
	WATERBURY.		
3197	John Brois..........	10.27	2.2
3176	John Crook.........	9.08	1.0
3184	Famous Lunch......	9.97	1.8
3192	Randays Lunch.....	10.49	2.5
3191	Star Lunch.........	10.86	2.8
3190	White House Lunch..	10.78	2.2
3194	The Why Lunch....	10.63	2.4
3175	O. Sampson.........	10.24	2.3
3181	Kelley's Restaurant..	11.29	2.8
	WESTPORT.		
3038	Ackerly Lunch......	10.89	2.3
	WEST SUFFIELD.		
01	F. W. Orr..........	12.06	3.1
	WILLIMANTIC.		
2416	Hyman Israel.......	10.53	2.0
2415	F. J. Kirtland.......	11.07	2.3
2420	A. Krug............	10.88	2.5
2421	T. F. Shea..........	10.69	2.0
	WINDSOR LOCKS.		
2992	Harry Brusie.......	11.42	2.8
	Skimmed Milk–conc'd.		
	NO ADDRESS.		
13633	John Wallin.........	10.34	2.2
12807	Name not given.....	11.30	2.6
12812	Name not given.....	10.20	2.0
	Skimmed and Watered Milk.		
	EAST HAVEN.		
14000	W. A. Bassett.......	9.92	2.2
	HARTFORD.		
12480	Hartford Lunch.....	7.87	1.9
	MERIDEN.		
12804	D. B. Allen.........	9.13	1.9
	NEW HAVEN.		
12878	Busy Bee Restaurant	10.72	2.7
12893	J. Joseph Lunch.....	8.86	1.6
	SHELTON.		
13212	Bodner's Lunch......	9.72	2.2
	SOUTH MANCHESTER.		
12315	Thomas Graham....	9.87	2.4
	STAMFORD.		
13049	Jessup Lunch.......	9.74	2.2

only two samples, Nos. **12328** and **12329**, prune pie and apple pie, respectively, both sold by the Connecticut Pie Baking Co., Hartford.

PORK SAUSAGE.

Twenty-two samples of Pork Sausage were submitted by the Dairy and Food Commissioner to be examined for "fillers." The substances used for this purpose are starchy products such as bread, cracker and biscuit wastes and permit of the absorption of excessive amounts of water and the use of lower grade meat stock. The use of fillers should be declared by proper labelling.

According to Leach[1] 1 per cent. or more of starch may be found in sausage arising from the spices used in seasoning, but in our experience this is rather too high, the starch content in products made without admixture of cereals being generally less than 0.5 per cent.

In only three samples examined was starch found in excess of 1 per cent. They were as follows:

12602. Sold by L. Lowenthal, Stratford Ave., Bridgeport. Contained 4.59 per cent. of starch.

12605. Sold by Stockman & Schiff, E. Main St., Bridgeport. Contained 1.59 per cent. of starch.

12612. Sold by Chicago Market, Main St., Bridgeport. Contained 1 08 per cent. of starch.

Vinegar.

The law requires that cider vinegar shall contain 1.6 per cent. of solids and 4 per cent. acidity.

Seven samples were submitted by the Dairy and Food Commissioner for examination as to identity and conformity to the state standard. Of these, one met the standard requirements, four were below standards in solids or acidity, or both, and two were distilled vinegars.

Ninety-nine samples have been sent to us by individuals. Of this number sixty-one were passed and thirty-eight were found deficient.

Wine.

A sample of Vista del Valle, a California wine of the Moselle type, was sent us by Dr. Potter, Director of the Memorial Laboratory and Clinic, Santa Barbara, Cal.

The analysis was as follows:

Specific gravity at 15.6° 0.9925; alcohol, by volume, 11.25 per cent; total sugars, as invert sugar, 0.06 gram per 100 cc.

This sample is of interest in connection with our previous analyses[2] of various types of wines with reference to their suitability for use in a diabetic diet.

[1] Food Inspection and Analysis, p. 185.

[2] Conn. Agr. Exp. Sta. Report, 1913, pp. 72 and 73.

Non-Alcoholic Beverages.

Three samples of this class of products have been examined.

9990 and **10328,** Pablo; **10329,** Weiss Imitation Beer.

The analyses are as follows:

No.	**9990**	**10328**	**10329**
Specific gravity at 15.6°	1.0207	1.0207	1.0022
Alcohol, by vol	0.42%	0.36%	4.62%
Solids	5.14	5.10	1.39
Sugars, as dextrose	4.80	4.82	1.03
Preservative	none	none	none

Sample **10329,** if an imitation, is a very faithful reproduction of the original as regards stimulating properties.

Syrups.

Three products of this class have been analyzed.

9876, Karo (blue label) and **9935,** Karo, maple flavor. The Corn Products Refining Co., New York.

9877. Domino Kanelasses. American Sugar Refining Co., New York.

The analyses are as follows:

No.	**9876**	**9935**	**9877**
Density, Baumé	39.9	38.7	40.7
Total solids	77.04%	74.69%	78.43%
Direct reducing sugar,			
as dextrose	32.00	27.81	.....
as invert sugar	.....	.....	42.08
Sucrose	.....	.....	26.60
Total sugars	.....	.....	68.68
Total sugars, as dextrose	71.38	70.00	.....
Ash	0.70	0.38	2.37

Miscellaneous Materials.

FOODS, ETC.

Miscellaneous foods, sent by private individuals and others and not included in previous classifications, have been examined as follows:

Cherries. **9893.** Liberty Cherries. The Liberty Cherry and Fruit Co., Covington, Ky. Labelled as containing sulphur dioxide and artificial color and flavor.

They were colored with permitted colors, napthol yellow S. and light green S. F. yellowish; contained 86.4 milligrams of sulphur dioxide per kilo, which is not an excessive amount, and had a pronounced mint flavor.

Virocacao. **10593.** The Virocacao Company, Inc., New York. Manufactured on the basis of egg, malt, milk, peptones, phosphates, cocoa, etc.

The analysis of the product is as follows:

Moisture	1.75%
Ash	8.51
Protein (N. 1.64%)	10.25
Fiber	0.65
Nitrogen-free extract	69.70
Fat	9.14
Direct reducing sugar, as dextrose	5.93
Increase after inversion, as sucrose	45.51
Starch	4.42
Total phosphoric acid	4.09
Lecithin phosphoric acid	0.016
Water-insoluble nitrogen	1.06
Coagulable nitrogen	0.15
Tannin-salt precipitable nitrogen	0.26
Resdiual nitrogen	0.17
Total nitrogen	1.64

The amount of lecithin phosphoric acid is too small to be convincing of the presence of an appreciable amount of whole egg; otherwise, the ingredients as stated appear to be substantiated.

Hebe. **9878.** The Hebe Company, Seattle, Wash. "Compound of evaporated skimmed milk and vegetable fat." Stated to contain 6% vegetable fat and 24% total solids. For coffee and cereals, baking and cooking.

Analysis showed the following composition:

Total solids	25.49%
Ash	1.58
Protein	6.38
Lactose	8.79
Fat	8.18
Constants of fat:	
Butyro-refract. at 40°	39.5°
Reichert-Meissel No	6.70

The product is true to its label. The milk fat removed has been replaced by adding cocoanut oil, as the flavor and the constants

of the fat indicate. Cocoanut fat is not an adequate substitute for milk fat as a food for children or invalids, but no such claim is made or implied for this preparation. For the purposes stated on the label it should be satisfactory.

Mammala. **10539.** The Mammala Corporation, 120 Liberty St., New York. Special dry milk for babies, invalids and convalescents. Pure fresh cow's milk modified by removing a part of the cream and adding a suitable portion of milk sugar. Net weight of contents 12⅓ ozs.

This product has the following composition:[1]

Net weight of contents	12.75 ozs.
Moisture	4.05%
Ash	5.75
Protein	25.78
Lactose	49.90
Fat	14.52
Starch	none
Sucrose	none

On the basis of 12 per cent. solids, this analysis reduces to 3.22 per cent. protein, 1.82 per cent. fat, 6.24 per cent. sugar, and 0.72 per cent. ash. This is the composition of milk with about one-half of the fat removed, reinforced with milk sugar, the other constituents remaining normal.

Krystalak. **11241.** The Dry Milk Co., 15 Park Row, New York. Dry skimmed milk. Contains no added sugar, no preservative and no adulterant of any kind. Contains 30 per cent. casein, 50 per cent. milk sugar and 7 per cent. milk salts. Net weight 1 lb.

Weight found	1 lb.
Moisture	5.05%
Ash	8.37
Protein	35.41
Fat	3.20
Lactose	48.20
Difference (+.23) deducted =	100.00

Lactora. Soluble Dry Milk. **11351.** The Dry Milk Co., Bainbridge, N. Y. Submitted by Miss Bixby, Board of Health, Bridgeport.

[1] See also Conn. Agr. Expt. Sta. Report, 1914, p. 336.

This product is dried skimmed milk, as shown by the following analysis:

Moisture	8.39%
Ash	7.74
Protein	32.47
Fat	2.60
Lactose	48.50
Undetermined	0.30
Total	100.00

Corn Meal. **11084** and **11085.** Eastern Flour and Merchandise Co., New Haven; **11116, 11117, 11118, 11119, 11120** and **11121.** Stoddard Gilbert Co., New Haven. These samples represented car lots of meal to be turned over to the Government for overseas shipment, provided they showed the required composition as regards moisture and fat content.

These ingredients were as follows:

No.	**11084**	**11085**	**11116**	**11117**	**11118**	**11119**	**11120**	**11121**
	%	%	%	%	%	%	%	%
Moisture.	12.79	12.25	12.92	13.40	11.95	12.34	13.19	13.25
Fat	1.19	3.45	2.40	0.82	4.30	2.89	3.15	2.77

Owing to the danger of spoilage through heating, shippers have found it necessary to insist upon a fixed correlation between moisture and fat, to insure a reasonable margin of safety. Thus the following limitations have been set for this purpose: 11.50 per cent. water, not over 3.00 per cent. fat; 12.00 per cent. water, not over 2.00 per cent. fat; and 13 per cent. water, not over 1.50 per cent. fat.

A sample of meal, **11346**, sent by County Agent B. W. Ellis, Putnam, suspected of being of inferior quality, was found to be below the average as regards protein but not below the minimum in that respect.

Rice Flour. **11362.** Submitted by Crouch and Plasman, Bridgeport, for examination as to genuineness. It showed the analysis of a typical rice flour and the microscope revealed no foreign starch.

Rye Flour. **10537.** Suspected of being other than rye flour. The sample contained 7.94 per cent. of protein, which is too low for a typical rye flour. The starch grains were much too small for rye, and closely resembled buckwheat.

Lye Hominy. **10534.** Stokely Brothers and Co., Newport, Tenn. This is a white corn treated with caustic soda solution to loosen the hull so that it can be removed. The hulled corn is then freed from alkali by repeated washings with water.

The net contents of the can was 1.013 grams, of which 471 grams was liquor and 542 grams was moist (drained) hominy. The analysis of each is as follows:

	Drained Hominy.	Liquor.
Water	77.98%	97.85%
Ash	0.64	0.71
Protein	1.93	0.06
Fiber	0.15	....
Starch	15.27	1.00
Other nitrogen-free extract	3.00	....
Fat	1.03	....
Undetermined	....	0.38
Total	100.00	100.00

The liquor is discarded when preparing the hominy for eating. About one-half of the ash constituents are thereby lost, but no considerable amount of other materials. The reaction of the liquor was very faintly alkaline.

Chicaros. **10542.** Large yellow peas, common in Italy. Submitted by Dr. Julia Teele for an opinion as to their suitability as a diabetic food.

They were analyzed as follows:

Moisture	6.40%
Ash	3.12
Protein	22.31
Fiber	1.50
Fat	5.99
Starch	37.97
Other nitrogen-free extract	22.71

The starch content is too high for a satisfactory diabetic diet.

Almond Chocolate Bars. **10786.** Made by Loeb's Diabetic Food Bakery, New York. The product is substantially the same in composition as was found on previous examination[1] in this laboratory, with the exception that it contained considerably more fat and correspondingly less nitrogen-free extract. There was no indication of added sugar, the sweetening agent being saccharin.

[1] Conn. Agr. Expt. Sta. Food and Drug Report, 1914, p. 246.

Breast Milk. Three samples of breast milk were analyzed as follows:

No.	**10953**	**11353**	**10620**
Solids	12.21%	13.52%	12.49%
Fat	3.83	4.80	3.90
Protein	2.17	8.46 (protein and sugar)	1.16
Sugar	6.21 (sugar and ash)		7.23
Ash		0.26	0.20

Nut Margarine. **10650.** Submitted by the Dairy and Food Commissioner on complaint of a purchaser, who had bought a considerable quantity, a large part of which had become rancid in storage.

No chemical examination was made. All fats tend to decompose and become rancid on long standing. Some are more prone to such change than others. Nut margarines are delicate products of which manufacturers do not encourage jobbers to carry a large stock, but rather to handle small lots to insure freshness of supply. There was no way of determining in this case whether rancidity was due to faulty manufacture or to subsequent improper handling and storage.

Vanilla Extract. **11218.** This was a very turbid preparation, purchased in bulk and contained 0.08 per cent. of coumarin.

Victor Butter Preserver. **11166.** The Victor Packing Co., Rockford, Ill. Submitted by the Dairy and Food Commissioner.

The product consists of about 37.5 per cent. of sugar, 60.0 per cent. of salt, with 1.58 per cent. of saltpetre, 0.44 per cent. potassium chloride and a trace of sulphate. Benzoates, borates and salicylates were absent. The preparation is used as an external preservative and is not objectionable.

Sample **11082,** a white salt thought to be saltpetre and proposed for use in the manufacture of sausage, was submitted by the Board of Health, New Haven.

The salt was found to be sulphate of soda containing much free sulphuric acid and would hardly be a success for the purpose intended.

Water. **10954.** The sample was submitted by R. E. Thompson, Greenwich, and contained a sediment, explanation of which was requested.

It was found to be hydrated oxide of iron due probably to contamination from the piping.

Whiskey. **10606.** Submitted for test of proof. It was found to contain 33.04 per cent. of alcohol which is 66 per cent. proof.

Beer. **11198 A** and **11198 B.** Samples were cloudy in appearance and thought to contain insufficient alcohol. They contained 4.58 and 4.36 per cent., respectively, which is normal alcoholic strength. The cloudiness was due to faulty sterilization.

Cider. **11277.** Sample sent for identification by Dr. Howd, Health Officer, Winsted. It contained 2.22 per cent. solids, 0.50 per cent. acidity and 5.94 per cent. alcohol by volume, with the physical properties of hard cider.

Other miscellaneous samples, eight in number, have been submitted. These included a sample of sulphur for determination of degree of purity; flowers of sulphur for mechanical analysis; linseed oil for degree of purity; aresnate of lead for analysis; two unknown salts for identification; a sample of soap and one of salt.

Silver Springs Salt. **10390.** For Live Stock. Sent by the Dairy and Food Commissioner. It contained 4.01 per cent. moisture; 76.24 per cent. sodium chloride; 17.62 calcium sulphate; a trace of magnesium, and 2.13 per cent. of undetermined substances.

The other samples require no comment.

FOODS SUSPECTED OF CONTAINING INJURIOUS FOREIGN SUBSTANCES.

During the past year the public press has frequently reported instances of suspicious destruction of, or injury to, consignments of food stuffs. This has resulted in a general suspicion of injurious substances in foods of daily consumption which for a time developed into a sort of hysteria.

Ground Glass. Of these injurious substances ground or powdered glass has been chiefly suspected. State and local food administrators, health and police officials, as well as private individuals, have submitted samples of food and confections suspected of containing this substance.

Forty samples have been examined. In thirty-one of these no evidence of glass was found. Silica (or sand), which is widely distributed in foods of vegetable origin, and crystalized sugar were the substances chiefly responsible for the alarm in these cases.

In six samples we detected no glass ourselves, but identified as glass small fragments to which our attention was called, or

which had previously been isolated, by the persons submitting the samples.

In three cases we detected glass as follows:

10812. Cooked meat. Sent by W. J. Rawlings, Chief of Police, New Britain. One fragment of glass weighing about ¼ grain was found, with smaller particles also present.

11086. Partially chewed chiclet. Sent by T. W. Farnam, Food Administrator, New Haven. Contained fine particles of glass.

10852. Canned Corned Beef. Sent by G. A. Shelton, Health Officer of Shelton, through the Dairy and Food Commissioner's Office. No analysis was necessary to detect glass in this sample. Large fragments were found weighing from fractions of a grain to over two grains and present in the proportion of 2.5 ozs. per pound of meat. Report was made to the proper authorities for investigation, the results of which have not come to our attention. This was evidently a case of sabotage.

Coarsely broken or chipped glass, if not detected earlier, would be found after being taken into the mouth, where obviously it might result in laceration of the mouth tissues or injury to the teeth. There is little likelihood of it getting beyond the mouth. The injurious effects of powdered glass are probably overestimated. It is reported to have been used as a remedy among the peasants of Eastern Europe. The ash of all vegetable matter contains substances which are like it in kind and quality, and familiar to us as silica or sand. Moreover particles of silicious material in vegetable ashes often show sharp and jagged edges when viewed under the microscope.

We have been interested in this connection in an opinion by Dr. Thomas Brown[1] whom we quote, not, perhaps as an authority on the physiological effects of ground glass, but because his comment is based upon much sense and some experiment. He says "That ground glass is poyson according unto common conceit I know not how to grant. Not only from the innocency of its ingredients, that is, fine sand, and the ashes of glass-wort of fearn, which, in themselves are harmless and useful; or because, I find it by many commended for the stone; but also from experience,

[1] Pseudodoxia Epidemica. Printed for the assigns of Edward Dod. London, 1669.

as having given unto dogs above a dram thereof, subtilly powdered in butter or paste, without any visible disturbance." Speaking of "Glass grossly or coursely powdered" he says, "that indeed is mortally noxious, and effectually used by some, to destroy Mice and Rats; for by reason of its acuteness and angularity, it commonly excoriates the parts through which it passeth, and solicits them into a continual expulsion. Thereupon, there ensues fearful symptons, not much unlike those which attend the action of poyson."

Poisonous Substances. Twenty-two samples were examined for poisons or suspicious substances.

10886. Cooked meat, submitted by the matron of a boarding school in this state, was found to contain 290 milligrams of copper per kilo. No arsenic was present.

10851. Cooked meat with the water in which it was cooked. The intense purple color of the solution was undoubtedly due to the dye or stain from the U. S. Inspector's stamp on the meat, which had not been removed before the meat was cooked.

10607, 10608, 10619. *Sugar.* This sugar, which was not suspicious in general appearance, dissolved in water with a deep blue color. No one would think of drinking the solution. On close inspection blue particles were seen distributed throughout the sugar. Two coal-tar dyes were isolated, one an unidentified blue and the other probably Orange II. We have no evidence that the color was poisonous, but probably no housewife would use the sugar, even with the certain knowledge that the color was harmless.

The contamination of the sugar may have been intentional, or it may have been accidental as, for example, coming from a container lined with blue paper to which source we once traced "suspicious blue particles" in flour.

This case also was reported to authorities for investigation.

None of the other samples examined require comment.

OTHER MATERIALS SUSPECTED OF CONTAINING POISON.

Eleven samples were submitted for examination.

10661. *Poisoned bait.* Sent by F. H. Plumb, Game Protector, Stafford Springs. Strychnine was present in considerable quantity.

Stomach contents of cow. Sent by J. J. Cavanek, D. V. M., Hartford. Distinct amounts of copper and arsenic were found.

11345. *Chicks thought to have died of arsenical poison.* Submitted by R. D. Martin, M. D. V., Bridgeport. Copper and arsenic were found in the crop, gizzard and liver of the birds, indicating death by Paris green.

11354. *Stomach contents of horse.* Sent by Dr. D. C. DeWolf, Bridgeport. Copper was detected but tests for arsenic were inconclusive.

Two exhibits submitted by State's Attorney Alling, New Haven, involved identification of copper sulphate, magnesium, sulphate and bicarbonate of soda; also the examination of an article of decomposed food in which copper and mercury were identified. Tests for arsenic and alkaloids were negative.

10814. A white powder submitted for identification by Chief Nichols, Police Department of Stratford. It was found to be Epsom salt.

11386. An unknown powder found scattered on the floor of the waiting room and toilet in a station of the New Haven Road. On complaint of passengers the railroad authorities investigated and sent 0.2 gram of the powder to us for examination. It was found to be white pepper.

The other samples require no comment.

II. DRUGS.

The work with this class of products during the past year has included the examination of four medicated wines, twelve proprietary remedies, twenty-four miscellaneous drugs and six samples of toilet preparations.

Medicated Wines.

Four preparations of this class have been examined.

Fairbanks Rock Cordial, Rye Compound. **8144.** P. J. Kennedy & Co., Boston. An excellent remedy for all throat and lung disorders. Analysis on label states 27.64 per cent alcohol, 19.10 per cent. solids, and 0.10 per cent. ash.

We find the composition of this preparation to be as follows:

Contents	13.1 fluid ozs.
Specific gravity at 15.6°	1.0400
Ethyl alcohol, by vol	29.24%
Methyl alcohol	none
Solids	18.77
Ash	0.03
Direct reducing sugar, as invert	2.96
Increase after inversion, as sucrose	14.92
Polarization, direct at 21°C	+15.20°
invert at 21°C	− 4.62°
Glycerin	trace
Alkaloids	none
Other vegetables extractives	present
Color	natural

Grimault's Cinchona and Iron Wine. **5575.** Stated to contain 15 per cent. alcohol. Net contents 240 grams. For stomach disorders, etc.

The analysis is as follows:

Contents	8.2 fluid ozs.
Specific gravity at 15.6°	1.0653
Ethyl alcohol	14.96%
Methyl alcohol	none
Solids	18.53
Ash	0.41
Direct reducing sugar, as invert	15.25
Increase after inversion, as sucrose	none
Glycerin	0.27
Alkaloids	0.18*
Other vegetable extractives	....
Iron	0.08
Tartaric acid	0.54
Sulphur dioxide, iodides, bromides	none
Color	natural

* Cinchona alkaloids.

Nourry's Wine, iodinated. **8005.** E. Fougera & Co., New York. Stated to contain 12 per cent. alcohol. Contents 300 grams. To be taken before and during the course of meals.

The analysis is as follows:

Contents	10.5 fluid ozs.
Specific gravity at 15.6°	1.0950
Ethyl alcohol	11.20%
Methyl alcohol	none

Solids	25.05%
Ash	0.36
Direct reducing sugar, as invert	17.48
Increase after inversion, as sucrose	0.30
Glycerin	5.96
Alkaloids	trace
Iodine	0.25*
Tannin	0.38
Tartaric acid	0.45
Sulphur dioxide and bromides	none
Color	natural

* Largely or entirely as iodide.

Quina Laroche. **8006.** E. Fougera & Co., New York. Complete extract of the three kinds of cinchona bark, red, yellow and gray. Remedy against difficult digestion, debility, etc. Stated to contain 17 per cent alcohol.

The anlysis is as follows:

Contents	8.3 fluid ozs.
Specific gravity at 15.6°	1.0855
Ethyl alcohol	16.28%
Methyl alcohol	none
Solids	23.85
Ash	0.27
Direct reducing sugar, as invert	21.23
Increase after reduction, as sucrose	0.55
Glycerin	0.53
Alkaloids	0.035*
Tartaric acid	0.23
Sulphur dioxide, iodides and bromides	none
Color	natural

* Cinchona alkaloids. No indication of cocaine.

These products are all closely alike in that they are wines or other alcoholic fluids reinforced with a little medicament in the form of vegetable extractives, but with not enough thereof to destroy the pleasing effect of the sweet hydro-alcoholic base.

Proprietary Remedies.

Twelve products of this class have been examined.

Arbolone. **9908.** The Blackburn Products Co., Dayton, Ohio. Compound for the treatment of obesity. Five-grain tablets. Price 75 cents per box.

Examination and analysis showed the following composition:

There were 54 tablets in the package weighing collectively 31.77 grams. Average weight per tablet 9.05 grains. Ash 31.16 per cent., chiefly calcium carbonate; total sugars, as dextrose, 36.00 per cent; starch, 7.29 per cent.; total organic iodine 0.021 per cent.; loss at 100° 2.37 per cent.; thyroid present.

These tablets are essentially thyroid and starch coated with carbonate of lime and sugar.

Cadomene. **9907.** The Blackburn Products Co., Dayton, Ohio. Tonic compound. Stated to contain in each tablet nux vomica 1/4 grain, zinc phosphide 1/20 grain, also calisaya bark, gentian, saw-palmetto, damiana and iron peptonate. Three-grain tablets, Price $1.00.

Examination and analysis showed the following composition:

There were 84 tablets weighing collectively 41.77 grams. Average weight per tablet 7.65 grains. Loss at 100° 1.98 per cent.; mineral matter (ash) 31.34 per cent. (includes 2.48 talc, 14.16 lime, 4.33 iron oxide, 0.44 zinc, 0.15 phosphorus, carbonates present); total sugars 41.64 per cent.; total alkaloids 0.68 per cent.—strychnine, brucine and quinine present; gentian, damiana and peptonate present.

Hypo-Nuclane. **9905.** The Blackburn Products Co., Dayton, Ohio. Carefully compounded of pure drugs and chemicals. For nervous ills, malnutrition and malassimilation, general debility, etc. Especially to increase weight. Sixty 3-grain tablets, $1.20.

Examination and analysis showed the following composition:

60 tablets averaged in weight 5.52 grains per tablet. Loss at 100° 1.23 per cent.; mineral matter (ash) 42.96 per cent. (includes lime 15.12, magnesia 2.85, sodium 3.09, potassium 1.60, iron 2.58; sulphates and carbonates present); phosphates, chlorides, nitrates, bromides and iodides absent; total phosphorus, chiefly as hypophosphites, 6.32 per cent.; total sulphur, chiefly as sulphate, 0.16 per cent.; total nitrogen 0.48 per cent.; total sugar, as dextrose, 26.20 per cent.; total alkaloids, strychnine identified, 0.24 per cent.; biliary products(?); emodin-like substances absent.

The tablets are orange colored, coated with carbonate of lime and sugar, and contain essentially hypophosphites, iron and strychnine with biliary products possibly present.

Fruitatives. **9900.** *Fruitatives Limited, Ogdensburg, N. Y.* "The laxative and healing properties of fresh ripe fruit—enhanced by special tonics and condensed into tablet or pill form." Stated

to be made from concentrated and intensified fruit juice, a special extract from seeds of nux vomica fruit, and special tonics and antiseptics.

Small packages containing 17 tablets sell for 23 to 25 cents. The 50 cent size package contains 45 tablets.

Examination and analysis showed the following composition:

Loss at 100° 3.78 per cent.; mineral ingredients (ash) 46.18 per cent., chiefly carbonate of lime with magnesia, sodium and potassium present; sugar, as dextrose, 27.28 per cent.; alkaloids 4.95 per cent., including 4.60 per cent. quinine with strychnine and brucine present; aloes and rhubarb present and possibly cascara, ginger and licorice; tests for fruit acids, citric and tartaric acids, were negative.

The medicament in these tablets is chiefly aloes, rhubarb and the alkaloids of cinchona and nux vomica.

Brazilian Balm. **9902.** B. J. Jackson & Co. A remedy for colds, grippe, influenza and a long list of other ailments including consumption and rheumatism. Also an antiseptic and healing agent for external use. Literature with the bottle states, among other things, that it contains no alcohol or narcotics, minerals, purgatives, or poison.

Examination and analysis showed the following composition:

A brown syrupy liquid with a wintergreen odor. Specific gravity at 15.6° 1.2404; alcohol 1.54 per cent.; solids, chiefly glycerin, 88.63 per cent.; ash 0.06 per cent.; tartar emetic 0.26 per cent.; no alkaloids were detected.

Tartar emetic is antimony and potassium tartrate and is a poisonous drug.

Preparations with this name have been the subject of two Notices of Judgment under the Federal Food and Drugs Act. From N. J. No. 4365 it appears that the remedy contains alcohol and tartar emetic, but the latter substance does not appear among the constituents as noted subsequently (N. J. No. 5929), from which it would appear that the formula for the product has been revised.

Linonine. **9904.** Kerr's Flaxseed Emulsion. The Kerr Chemical Co., Danbury, Conn. The formula on the label states the following ingredients: Oils of flaxseed, cassia, eucalyptus and betula; Irish moss and glycerin.

Examination and analysis showed the following composition:

Specific gravity at 15.6° 0.9959; alcohol none; mineral matter (ash) 0.28 per cent.; volatile oils present, cassia and wintergreen detected; fixed oil, identified as linseed, 20.75 per cent.; glycerin 2.31 per cent.; Irish moss present.

Radway's Ready Relief. **7909.** Radway and Co., New York. For external use as a liniment and also for internal use for sour stomach, heartburn, diarrhoea, etc. Stated to contain 27.00 per cent. alcohol. Contents 3½ fluid ozs. Price 50 cents.

Examination and analysis showed the following composition:

Contents 3.2 fl. ozs.; specific gravity a 15.6° 0.9730; alcohol 25.00 per cent.; methyl alcohol none; solids 1.94 per cent.; ash 0.77 per cent. (includes potassium, sodium and carbonates); nitrogen 1.00 per cent. (in ammoniacal form); capsicum, camphor and small amount of soap present; emodin-like substances, glycerin and sugar none; tests for alkaloids inconclusive.

Seng. **9903.** Sultan Drug Co., St. Louis, Mo. A digestive secernent. Indicated in indigestion malassimilation, malnutrition, wasting diseases, etc., in which it is desired to stimulate the secretory glands of the digestive organs. Contains 18 per cent. alcohol.

Examination and analysis showed the following composition:

Specific gravity at 15.6° 1.0188; alcohol 19.90 per cent.; total solids 11.80 per cent.; mineral ingredients (ash) 0.37 per cent., includes traces of lime, potassium, sodium, phosphates and carbonates; total sugar as dextrose 0.90; glycerin 10.41 per cent.; emodin-like substances not found; alkaloids none; aromatic taste resembling ginseng.

This product is essentially an alcoholic solution containing glycerin and sugar, with some aromatic vegetable principle, possibly ginseng.

S. S. S. **7910.** The Swift Specific Co., Atlanta, Ga. Purely vegetable. Said to contain *Chionanthus Virginica* root, prickly ash root, sumac root and sarsaparilla root. Label states 15 per cent. alcohol. Contents 12 fl. ozs. Price $1.00.

Examination and analysis showed the following composition:

Contents 11.8 fl. ozs.; specific gravity at 15.6° 1.0107; alcohol 14.36 per cent.; methyl alcohol none; solids 7.74 per cent.; ash 0.15 per cent.; sugars trace; glycerin 4.41 per cent.; alkaloids trace; tannin and color principles large amount, source undetermined; sarsaparilla present; emodin-like substances, iodides and bromides were not detected.

This product is an alcoholic solution containing glycerin, and vegetable principles of which only sarsaparilla was identified.

Taps. **7948.** Taps Pharmacal Co., New York. Stated to contain cascara, aloes, podophyllum, phenolphthalein and leptandrin.

Examination and analysis showed the following composition:

Thirty-one heart-shaped tablets averaging in weight 4.37 grains each. Loss at 100° 4.36 per cent.; mineral matter (ash) 22.26 per cent.; ash insol. in acid 3.94 per cent.; sugar, as dextrose, 31.20 per cent.; phenolphthalein 2.20 per cent.; cascara, aloes and probably podophyllum present; leptandrin not identified; alkaloids(?).

They are laxative pills coated with sugar and mineral substance and contain phenolphthalein with aloes, cascara and probably other vegetable principles. Presence of alkaloids was not conclusively shown.

Orchard White. **9901.** The Edward Wesley Co., Cincinnati, Ohio. Label states an alcohol content of 11 per cent. It directs to mix the contents of the bottle with lemon juice; to be used as a massage lotion for the complexion. Not intended for curative or medicinal purposes.

Examination and analysis showed the following composition:

A white emulsion with the odor of bitter almonds. Specific gravity at 15.6° 1.0035; alcohol by vol. 12.00 per cent.; solids 3.55 per cent.; mineral constituents (ash) 1.29 per cent.; bismuth, equivalent to bismuth tri-oxide, 0.78 per cent.; boric acid 1.28 per cent.; tragacanth present.

The analysis shows that the preparation is an alcoholic suspension of gum tragacanth, containing boric acid and bismuth. The purchaser adds citric acid in the form of lemon juice.

Bon Opto. **9899.** Valmas Drug Co., Detroit, Mich. Contains, according to formula on the carton, chloretone, zinc sulphate soldim chloride, boric acid and menthol.

The $1.00 size package contained 14 white tablets weighing about 5 grains each.

Examination and analysis showed the following composition:

Boric acid 39.06 per cent.; sodium chloride 39.40 per cent.; zinc and sulphuric acid equivalent to 4.13 per cent. of crystalized zinc sulphate; menthol and chloretone present.

Druggists' Stock Preparations.

SAMPLED BY THE STATION AGENT.

Tartar Emetic. This is antimony and potassium tartrate, $K(SbO)\ C_4\ H_4\ O_6 + \frac{1}{2}\ H_2O$, and is required by the U. S. Pharmacopoeia to be not less than 98.5 per cent. pure. Since the salt loses its water of crystalization upon exposure to air, it should be kept in securely closed containers. Each gram of the salt corresponds to not less than 59.3 cc of tenth-normal iodine solution.

Five samples were examined none of which fell below the U. S. requirements. In four cases results were somewhat too high, due to efflorescence of the salt. All were sold with a "poison" label, with one exception, in which case the mark "for external use only" appeared.

SUBMITTED BY THE DAIRY AND FOOD COMMISSIONER.

Tincture of Iron. This is a hydro-alcoholic solution containing ferric chloride equivalent to not less than 4.48 per cent. of iron, and should contain 63 per cent. of alcohol.

The two samples examined differed from the U. S. P. standard in one or both particulars.

12236. Sold by Alex. C. Prinz, Ideal Pharmacy, 190 Main St., Danbury.

It contained 3.70 per cent. of iron and 70.65 per cent. of alcohol. Variation from alcoholic strength not tolerated. Found deficient in iron.

12237. Sold by M. Soroch, 256 Main Street, Waterbuy.

It contained 3.55 per cent. of iron and 68.55 per cent. of alcohol. Sample passed as to alcoholic strength. Found deficient in iron.

Tinture of Iodine. This is an alcoholic solution of iodine and potassium iodide. The U. S. P. requires that it shall contain in 100 mils not less than 6.5 nor more than 7.5 grams of iodine, and not less than 4.5 nor more than 5.5 grams of potassium iodide. The alcoholic strength should be 83 per cent.

One sample, **12238,** sold by J. A. Notkins & Bro., 198 Congress Ave., New Haven, was examined.

It contained 84.95 per cent alcohol; 6.17 grams of iodine and 4.98 grams of potassium iodide per 100 mils.

Sample was passed with respect to alcoholic strength and content of potassium iodide, but found deficient in iodine.

Spirit of Nitrous Ether. This is an alcoholic solution of ethyl nitrite containing not less than 3.5 per cent. nor more than 4.5 per cent. of ethyl nitrite and should contain 92 per cent. of alcohol.

One sample, **12235**, sold by A. B. Pixley, 14 No. Main St., Wallingford, was found to meet the U. S. P. requirements in both particulars.

Fluid Extract of Nux Vomica. One hundred mils of this preparation are required to yield not less than 2.37 nor more than 2.63 grams of nux vomica alkaloids.

One sample, **12233,** sold by Malinewsky and O'Brien, 487 Main St., New Britain, was found to meet the U. S. P. requirements.

Wine of Colchicum. The National Formulary requires that 100 mils of *Wine of Colchicum corm* shall yield not less than 0.126 nor more than 0.154 gram of colchicine. It requires that *wine of colchicum seed* shall contain in 100 mils not less than 0.036 nor more than 0.044 gram of colchicine.

One sample, **13500,** dispenser not known, was found to contain 0.096 gram colchicine.

Wine of Colchicum Seed. **13516.** Sent by Dr. O. K. Isham, High St., Hartford.

The sample contained 31.50 per cent. of alcohol, and 0.070 gram of colchicine per 100 mils. The alkaloidal strength is practically double the minimum N. F. standard and more than 50 per cent. in excess of the maximum standard.

Soap Liniment. This U. S. P. preparation is a hydro-alcoholic solution of soap, camphor and oil of rosemary. It should contain 66 per cent. of alcohol. There are no standards prescribed for the other ingredients.

One sample, **12234**, sold by Fred S. Sanford, Shelton, was examined and passed.

Bismuth Subnitrate Tablets. One sample, **13501**, dispenser unknown, submitted by the Deputy Commissioner, and labeled to contain 2 grains bismuth subnitrate, was examined and found to be correctly labeled.

Another sample, **12245**, submitted to the Dairy and Food Commissioner by Dr. O. K. Isham, Hartford supposed to contain 2 grains of bismuth subnitrate per tablet, was found to contain none of that drug.

Four samples of tablets, Nos. **10688, 10689, 10690** and **10691,** were submitted. They consisted largely (from 92 to 95 per cent.)

of milk sugar with traces of iron, lime, sodium, potassium and alüminum. Tests for alkaloids were negative, except in sample **10688**, where a doubtful test was observed. No mercury or nitroglycerin was found. Conclusive evidence of specific medicaments could not be obtained.

Toilet Preparations.

Under the Act of Legislature forbidding the use of wood alcohol in any preparation intended for internal or external use, six samples have been examined, all submitted by the Dairy and Food Commissioner.

Four were deficient in grain alcohol but none contained wood alcohol. This is an improvement over last year when, of twenty-five samples examined, wood alcohol was found in twelve.

Miscellaneous Preparations Submitted by Individuals.

Morphine Sulphate Tablets. **11280.** Submitted by Dr. Gustavus Eliot, New Haven. They were supposed to contain ¼ grain of morphine sulphate per tablet and were suspected of being deficient.

They were found to contain 0.234 grain per tablet and were satisfactory.

Brilliantine. **10782.** A case of suspected poisoning through the use of a hair dressing was referred to us by the Department of Health, New Haven.

No evidence was found of any substances to which the symptoms described could be attributed.

Liniment. **10636.** Submitted by W. J. Rawlings, Chief of Police, New Britain.

The so-called liniment consisted of at least 90 per cent. of kerosene, with a small amount of turpentine and camphor present.

Turpentine. **10630.** The F. E. Spencer Co., New Haven.

No mineral oil was found. Sample was satisfactory.

Gen-Sen. **11542.** Submitted by the War Bureau, New Haven. A remedy of which free samples were being distributed from house to house.

It consisted essentially of aloes and Epsom salt. No alkaloids were present.

SUMMARY.

MATERIALS.	Sampled by: Station Agent.	Sampled by: Dairy and Food Com'r.	Sampled by: Individuals.	From all sources.	Found adulterated, below standard, or [illegible]
FOODS.					
Breakfast foods, Health foods, etc	8	2	0	10	
Butter	0	26	1	27	
Cooking fats	7	0	0	7	
Cream	0	6	5	11	
Eggs, dried	3	0	0	3	
Egg substitutes	3	0	1	4	
Foods, for saccharin only	0	36	0	36	
Fruit juices and carbonated beverages	48	0	0	48	[illegible]
Milk	0	1439	40	1479	6[illegible]
Non-alcoholic beverages	3	0	0	3	
Nut margarine	8	0	0	8	
Oleomargarine	5	13	0	18	
Olive oil	2	96	3	101	[illegible]
Sausage	0	22	0	22	
Substitute flours	16	0	0	16	
Syrups	3	0	0	3	
Tea	64	0	0	64	
Vinegar	0	7	99	106	[illegible]
Wine	0	0	1	1	
Miscellaneous	3	2	108	113	
Total	**173**	**1649**	**258**	**2080**	**8[illegible]**
DRUGS.					
Druggists' Stock preparations	5	14	0	19	
Medicated wines	4	0	0	4	
Proprietary remedies	12	0	0	12	
Toilet preparations	0	6	0	6	
Miscellaneous	0	0	5	5	
Total preparations	**21**	**20**	**5**	**46**	
Total for foods and drugs	**194**	**1669**	**263**	**2126**	**8[illegible]**

A CORRECTION.

In our Report for 1916, Table XVI, page 250, sample **11553** is accredited to the Harvey Co., Saratoga Springs, N. Y. This was the original information furnished us, but doubt arose later as to its identity and the sample was, therefore, not discussed in the text of the Report, and should not have been included in the tabulation of weight variations.

EIGHTEENTH REPORT

OF THE

STATE ENTOMOLOGIST

OF

CONNECTICUT

FOR THE YEAR 1918

(Being Bulletin 211 Connecticut Agricultural Experiment Station)

BY

W. E. BRITTON, Ph.D.

State Entomologist

New Haven, Conn.

1919

CONNECTICUT AGRICULTURAL EXPERIMENT STATION.

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Vegetable Growing.	W. C. Pelton, B.S.

* Absent on leave. In service of the United States.

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BULLETIN 211

EIGHTEENTH REPORT

OF THE

State Entomologist of Connecticut

To the Director and Board of Control of the Connecticut Agricultural Experiment Station:

I submit herewith the manuscript of my eighteenth report as State Entomologist of Connecticut for the fiscal year ending September 30, 1918. It includes brief reports of the inspection of nurseries, imported nursery stock, apiaries and suppressing the gipsy moth, provided for by act of the legislature; also separate accounts of a number of insect pests embodying the results of study and observation of members of the staff of this department; and finally a discussion of the European Corn Borer a destructive pest now present in Massachusetts, and greatly menacing Connecticut though happily not yet known to be present within the State.

Respectfully submitted,

W. E. BRITTON,

State and Station Entomologist.

REPORT OF THE RECEIPTS AND EXPENDITURES OF THE STATE ENTOMOLOGIST FROM OCTOBER 1ST, 1917, TO SEPTEMBER 30, 1918.

RECEIPTS.

From E. H. Jenkins, Treasurer	$6,000.00	
Account of 1917, Balance	986.71	
State Comptroller, Gipsy Moth Acct	257.09	
L. Hershman, old paper	1.53	
M. P. Zappe, Automobile Mileage	9.72	
W. E. Britton, " "	3.96	
		$7,259.01

EXPENDITURES.

For Field, Office and Laboratory Assistance:

B. H. Walden,* salary	$1,166.62	
Q. S. Lowry,** "	583.30	
M. P. Zappe, "	1,399.96	
K. F. Chamberlain, "	189.57	
J. S. Miller, "	18.00	
Grace A. Foote,*** "	675.00	
Martha de Bussy, "	78.60	
		$4,111.05

* Remainder paid from appropriation for elimination of mosc

** Resigned March 1st to accept a higher salary elsewhere.

*** Resigned August 10th to accept a higher salary elsewhere.

EXPENDITURES (*Continued.*)

Printing and Illustrations	$8.40	
Postage	70.76	
Stationery	23.63	
Telegraph and Telephone	2.85	
Office Supplies	9.50	
Library	108.80	
Laboratory Supplies	63.60	
Express Freight and Cartage	6.51	
Machinery, Tools and Supplies	851.72	
Travelling Expenses	308.20	
Insurance	123.61	
Automobile Tires and Repairs	129.67	
Balance, cash on hand	1,440.71	
		$7,259.01

Memorandum:—This account of the State Entomologist has been audited by the State Auditors of Public Accounts. The item of $257.09 credited as having been received from the State Comptroller is a transfer from the appropriation for suppressing gipsy and brown-tail moths and for inspecting imported nursery stock, and covers the time and automobile mileage while members of the department force were engaged in inspecting imported nursery stock.

PUBLICATIONS OF ENTOMOLOGICAL DEPARTMENT, 1918.

By W. E. Britton:

Seventeenth Report of the State Entomologist (Bulletin 203) 142 pages, 4 figures, xxxii plates; 10,000 copies distributed in August.

Report of Committee on Injurious Insects, Proceedings Connecticut Pomological Society, 2½ pages, page 46, May, 1918.

The Apple Aphids and the False Red-Bug, Proceedings Connecticut Pomological Society, 5 pages, 4 illustrations, page 63, May, 1918.

Report of Committee on Insects and Diseases, Report Connecticut Vegetable Growers' Association, 3 pages, page 11, May, 1918.

About Mosquitos and Flies, Bulletin New Haven Board of Health, 3 pages, May, 1918.

Some Insect Pests of Cultivated Plants, The Garden Guide, 17 pages, illustrated, page 260, March, 1918. A. T. DeLaMare Company, Inc., New York.

Some Insects Injuring Nut Trees, Proceedings Northern Nut Growers' Association, Eighth Annual Meeting, Sept. 5 and 6, 1917, 7 pages, page 73, 1918.

Prune Heavily and Burn Twigs to Destroy Pests, Connecticut Agricultural College Press Bulletin, 1-3 column, April 17, 1918.

Spraying as a Preservative, Connecticut Agricultural College Press Bulletin, 1 column, May 15, 1918.

Worm Attacking Iris Roots, The Florists' Exchange, Vol. xlvi, page 245, August 17, 1918. (Brief note.)

By W. E. Britton and G. P. Clinton:

Spray Calendar (Bulletin 199) 48 pages, with card back and 97 illustrations; 11,000 copies distributed in February, 1918.

By A. W. Yates, Apiary Inspector:

Beekeeping for Connecticut (Bulletin 205) 24 pages, 19 figures, 4 plates; 10,000 copies distributed in August, 1918.

By H. W. Coley, Apiary Inspector:

Diseases of Bees; Their Detection and Treatment, Bulletin of Immediate Information, No. 8, 4 pages; 2,000 copies, issued in May, 1918.

SUMMARY OF INSPECTION AND OFFICE WORK.

285 samples of insects received for identification.
88 nurseries inspected.
87 regular certificates granted.
13 parcels of nursery stock inspected and certified.
30 orchards and gardens examined.
73 shipments, containing 387 cases, 830,035 plants imported nursery stock inspected.
21 shipments or 28.7 per cent. found infested with insects or fungi.
395 apiaries containing 3,047 colonies inspected.
39 apiaries containing 99 colonies found infested with European foul brood.
4 apiaries containing 10 colonies found infested with American foul brood.
1 apiary containing 1 colony found infested with pickled or sacbrood.
1 apiary containing 1 colony found infested with bee paralysis.
1774 letters written on official work.
368 post cards written on official work.
78 reports of inspection to Federal Horticultural Board.
740 bulletins, etc., mailed on request or to answer inquiries.
43 packages sent by mail or express.
17 lectures and addresses made at institutes, granges, etc.

DEPARTMENT STAFF.

W. E. BRITTON, Ph.D. .... *State and Station Entomologist.*
B. H. WALDEN, B.Agr. .... *First Assistant.*
*QUINCY S. LOWRY, B.Sc. .... *Assistant.*
MAX P. ZAPPE, B.S. .... *Assistant.*
**IRVING W. DAVIS, B.Sc. ..*Assistant and Deputy in Charge of Moth Work.*
JOHN T. ASHWORTH .... *Assistant and Acting Deputy, Moth Work.*
†MISS GRACE A. FOOTE, B.A. .... *Clerk and Stenographer.*
‡MISS MARTHA DE BUSSY .... *Clerk and Stenographer.*

H. W. COLEY, Westport
A. W. YATES, Hartford } .... *Apiary Inspectors.*

* Resigned March 1, to accept a position in the Bureau of Entomology.
** On leave of absence from July 1, to enter U. S. Military Service.
† Resigned August 10.
‡ Beginning August 26.

A few changes have taken place in the staff during the year. After five years of satisfactory and efficient service as assistant, Mr. Quincy S. Lowry resigned to take effect March 1, to accept a position with increased salary as extension entomologist in truck crop insects in the Bureau of Entomology, U. S. Department of Agriculture. Mr. Lowry has been assigned to the state of Massachusetts with headquarters at Amherst.

Mr. Irving W. Davis at his own request was granted a leave of absence from July 1, in order to enter the military service of his country. He has since enlisted in the Marine Corps. During his absence the gipsy moth work will be in charge of Mr. John T. Ashworth. Mr. Ashworth has worked as an assistant to Mr. Davis since June 1, 1917, and is thoroughly familiar with all phases of the work.

Miss Grace A. Foote, who has served faithfully and efficiently as clerk and stenographer for more than three years, resigned August 10, to accept another position with increased salary. Her place has been filled by the appointment of Miss Martha de Bussy, who entered upon her duties August 26.

Messrs. Walden and Zappe have continued as assistants and have both aided in the general work of the department and in inspecting nursery stock. Mr. Walden has devoted a portion of his time (4 months) to supervising the mosquito maintenance work as deputy to the Director, and during this time his salary was paid from the Station funds or from the appropriation for mosquito control work. Mr. Walden has also done most of the photographic work of the department. Mr. Zappe has followed out the life cycle of the semi-tropical cockroach *Pycnoscelus surinamenses* Linn, in the laboratory, and has been in charge of field spraying experiments to control potato and apple insects. The first half of April he was assigned to scouting for the Oriental Peach Moth, *Laspeyresia molesta* Busck, in the southeastern part of the state with Mr. E. D. Brown of the Bureau of Entomolgy.

From July 8 to September 21, Mr. Kenyon F. Chamberlain of Cornwall was employed as assistant and helped inspect the nurseries, and also aided in spraying and in photographing insects.

Messrs. H. W. Coley and A. W. Yates as in preceding years have made the apiary inspections on a *per diem* basis.

All members of the staff, and others mentioned above have worked faithfully, conscientiously and efficiently and their services are appreciated.

NEW EQUIPMENT.

A "model 90, Overland" touring car was purchased October 1st, 1917, for the general use of the department with a considerable saving in time and money, in travelling about the state.

In the gipsy moth work, a used "Buick light six" touring car was purchased in the spring. A new auto truck power sprayer was also purchased and proved very necessary and effective in the control of the gipsy moth.

CHIEF LINES OF WORK.

The required work of inspecting nurseries, imported nursery stock, apiaries, and suppressing the gipsy and brown-tail moths has been carried along in the usual manner and is described in the pages of this report.

Some attention has also been paid, chiefly by Mr. Walden, to the question of mosquito elimination. Mr. Zappe and the Entomologist have continued observations on the insects attacking squashes, pumpkins, melons and cucumbers in Connecticut and have experimented with various methods and applications for their control.

The outbreak of the potato aphid, *Macrosiphum solanifolii* Ashm. required considerable attention and spraying tests were conducted at the Station farm at Mt. Carmel to control the pest. The Entomologist has also made observations on potato insects for a number of years and a paper embodying these has just been published as Bulletin No. 208 of this Station.

Mr. Zappe has continued his studies and observations on a species of sawfly attacking Austrian pine and has also found time for laboratory studies on the development of the cockroach *Pycnoscelus surinamensis* Linn which was found last year causing much injury in one of the large commercial greenhouses of the state.

On account of the conditions caused by the war the production of food has been of prime importance and war gardens have been planted and cultivated in every town and city in the State. Though the larger cities have garden supervisors, and the Bureau of Entomology has furnished an extension entomologist in the person of Mr. George M. Codding, for work in Connecticut, many demands have

been made on the entomologist for advice and instruction about dealing with the insect pest of these gardens.

The requests come by telephone, by mail and through personal conferences with the workers. It has ever been the policy of this department and of the Station to render the greatest amount of service possible either directly, or through co-operation with other agencies. The department therefore has been in direct contact with many owners, with most of the paid supervisors, and with the Farm Bureau and other extension workers. Co-operating with Mr. Codding, the department supplied a portion of the exhibit on war gardens shown at Charter Oak and Berlin fairs as a part of the exhibit of the State Council of Defense.

This department has also co-operated with the Bureau of Entomology in searching for the possible occurrence of the Oriental Peach Moth, *Laspeyresia molesta* Busck and was asked to recommend a man who could be employed by the Bureau for scouting work. After a long search Mr. E. D. Brown of Clinton was obtained, and began work April 1st, 1918. Mr. Zappe worked with him for the first ten days with the automobile to get the work started aright. Until after October 1st, Mr. Brown worked in the state, finding evidences of this pest along the coast. He was then sent into Rhode Island and Massachusetts, but while in Connecticut, he reported to this office regularly and his itinerary was in a large measure directed by the Entomologist.

After Mr. Lowry resigned, on account of the scarcity of men and their need in military service it was decided not to fill his place at once but to try and do the necessary work with the reduced force. Hence it has been impossible to carry on the usual or the desired amount of investigation. Some time has been given to the papers prepared for the State Geological and Natural History Survey, which will not be published until after the war ends. Considerable work has also been done on the insect collection and in indexing in the department library.

Since March the Entomologist has served as Chairman of the Committee on Food of the New Haven War Bureau.

The following pages give detailed accounts of the principal activities of the department for the year.

ISPECTION OF NURSERIES.

The work of inspecting the growing nursery stock of Connecticut was commenced on August 13th and finished on October 16th. Most of the work was done by Messrs. M. P. Zappe, B. H. Walden and K. F. Chamberlain, but they were assisted by Mr. E. D. Brown of the Bureau of Entomology who was scouting for the Oriental Peach Moth *Laspeyresia molesta* Busck, and by W. E. Britton. Mr. George E. Graham of the Botanical Department worked one day in one of the large nurseries on the lookout for pine blister rust, and Mr. A. A. Saunders of the blister rust inspection service examined all the currants in another large nursery.

The Overland touring car was used to transport the men and was kept in constant use for over two months. Practically all of the 86 nurseries were reached in this way, and a considerable saving in time and railroad fares was affected.

The nurseries were given thorough inspection and all trees, shrubs and plants found infested with important pests, were marked. The owner or manager was informed regarding them and carried out directions about the proper treatment or destruction of the infested plants in order to free the nursery from these pests. In no case was a certificate granted until these directions had been carried out.

In 32 nurseries no pests were found. The following pests were each found in the number of nurseries indicated:

Insects; oyster-shell scale 39; San José scale 18; scurfy scale 9; pine leaf scale 7; elm scale 2; spruce gall aphid 15; pine weevils 5; apple aphids, ash borer, linden borer, lilac borer, white elm scale, rose scale and imported European sawfly, one each.

Plant diseases; poplar canker 6; chestnut blight, blister rust on currants, and fire blight, one each.

Of course certain common insects such as aphids, fall webworm, yellow-necked caterpillars, white-marked tussock moth, red-humped caterpillars, etc., are found nearly everywhere and nurseries are no exception. These were not, therefore, taken into account, except in severe infestations.

Attention should here be called to the great prevalence, both in 1917 and 1918 of the oyster-shell scale *Lepidosaphes ulmi* Linn. In fact for the past three years this has been recorded in a greater number of nurseries than has the San José scale *Aspidiotus pernici-*

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Attention should here be called to the great prevalence, both in 1917 and 1918 of the oyster-shell scale *Lepidosaphes ulmi* Linn. In fact for the past three years this has been recorded in a greater number of nurseries than has the San José scale *Aspidiotus pernici-*

ciosus Comst., which is now on the wane even as a pest of nursery stock. But the oyster-shell scale heads the list of pests, and though easy to control where attention is given it, is of serious importance on stock that is allowed to shift for itself. Consequently much stock had to be destroyed, and more pruned back to remove the infestation.

The poplar leaf beetles *Lina scripta* Fabr. and *L. lapponica* Linn. were not noticed at all, though quite abundant in three nurseries in 1917. The tulip tree scale *Toumeyella liriodendri* Gmel. also was conspicuous by its absence in 1918, though it was reported from six nurseries in 1915, from one in 1916, and from four in 1917. The Oriental peach moth *Laspeyresia molesta* Busck was not found in any nursery. The pine blister rust was found only in one nursery and that in the aecial and telial forms on the topmost leaves of red currants.

Besides these regular nursery inspections, a number of separate parcels have been examined and certified so that they could be shipped. In some cases the certificates were issued to persons not in the nursery business who wished to send trees or shrubs to their friends, and such shipments would not be accepted by common carriers unless accompanied by official certificates of inspection because most states require it. Some such certificates have been issued to nurserymen so that they might ship before their nursery was put in shape to receive the general certificate covering all the stock. During the year 13 such parcel certificates have been issued.

Two nurseries did not succeed in cleaning up in season to receive their certificates last year. Consequently their names did not appear on the published list. These were inspected in the spring and certificates issued, and were again inspected with the other nurseries in the Fall. Therefore 88 nursery inspections have been made and 87 regular certificates granted.

Of the 85 names on the nurserymen's list for 1918, three are new, and the list contains two more names than the list of last year. Three of the old firms have gone out of the nursery business, but the number is kept good by those who failed to make the list last year.

The area devoted to nursery stock has not changed greatly from last year though on account of the shortage of labor and the necessity of growing food, has been curtailed somewhat. It amounts to about 1,556 acres.

The list for 1918, together with location, acreage, date and number of certificate of each is given below:

NURSERY FIRMS IN CONNECTICUT RECEIVING CERTIFICATES IN 1918.

Name of Firm	Address	Acreage	Certificate Issued	No. of Certificate
Barnes Bros. Nursery Co	Yalesville	150	Sept. 5	907
Beattie, Wm. H	New Haven	1	Feb. 18	981
Bertolf Bros	Sound Beach	25	Oct. 10	942
Bowditch, J. H	Pomfret Centre	8	Aug. 29	899
Brainard Nursery & Seed Co	Thompsonville	6	Oct. 1	925
Braley & Co	Burnside	1	Aug. 29	900
Bretschneider, A	Danielson	1	Sept. 7	908
Brooks Bros	Westbrook	1	Sept. 20	916
Burr & Co., C. R	Manchester	500	Sept. 23	919
Burroughs, Thos. E	Deep River	3	Sept. 20	914
Chapman, C. B	Groton	1	Sept. 4	902
Chapman, C. E	North Stonington	4	Aug. 28	898
Conine Nursery Co., The F. E	Stratford	50	Oct. 3	928
Conley, L. D	Ridgefield	3	Oct. 14	945
Conn. Agricultural College (Prof. S. P. Hollister)	Storrs	2	Oct. 31	961
Conn. Agri. Experiment Station (W. O. Filley, State Forester)	New Haven	1	Sept. 19	912
Conway, W. B	New Haven	1	Dec. 9	979
Crofut & Knapp Farm	Norwalk	60	Nov. 14	969
Cross Highway Nurseries	Westport	6	Oct. 18	952
Dallas, Inc., Alexander	Waterbury	3	Nov. 19	971
Dowd, Frank C	Madison	3	Oct. 31	962
Elm City Nursery Co., Woodmont Nurseries, Inc	Woodmont & New Haven	155	Sept. 23	917
Fairfield Landscape & Nurseries Co	Cannon Station	5	Oct. 18	951
Gardner's Nurseries	Cromwell	10	Dec. 6	977
Geduldig, G., Estate of	Norwich	1	Oct. 9	939
Goodwin Associates, Inc., The James L	Hartford	1	Nov. 9	966
Hartford Park Commissioners (G. A. Parker, Supt.)	Hartford	1	Oct. 30	958
Heath & Co	Manchester	5	Sept. 26	923
Hilliard, H. J	Sound View	1	Oct. 9	941
Holcomb, Irving	Simsbury	1	Sept. 4	901
Horan & Son, Jas	Bridgeport	1	Oct. 3	929
Houston & Sons, J. R	Mansfield	4	Nov. 12	968
Hoyt's Sons Co., Inc., The Stephen	New Canaan	300	Nov. 15	970
Hubbard & Co., Paul M	Bristol	12	Nov. 7	965

NURSERY FIRMS IN CONNECTICUT RECEIVING CERTIFICATES IN 1918—*Cont'd.*

Name of Firm	Address	Acreage	Certificate Issued	No. of Certificate
Hunt & Co., W. W.	Hartford	12	Oct. 4	932
Intravaia, Joseph (2)	Middletown	1	Oct. 1	927
Isselee, Charles	Darien	3	Oct. 29	957
Kelley, James	New Canaan	1	Sept. 13	909
Kellner, Herman H	Danbury	1	Oct. 14	944
Larkin Bros., The	New London	1	Sept. 23	918
Long, J. A	East Haven	1	Nov. 19	972
Mallett Co., George A	Bridgeport	1	Dec. 6	978
Maplewood Nurseries (T. A. Peabody, Mgr.)	Norwich	1	Oct. 9	940
Marigold Farm (H. Kelly, Prop.)	New Canaan	1	Sept. 13	910
McDermott, E. F	Windsor	1	Nov. 1	963
Meier & Gillette	West Hartford	2	Nov. 4	964
Millane Tree Expert Co., The	Middletown	1	Oct. 4	934
Munro, Charles	New Haven	1	Oct. 7	935
New Haven Nurseries	New Haven	10	Oct. 29	956
New Haven Park Commissioners (G. X. Amrhyn, Supt.)	New Haven	30	Nov. 25	974
New London Cemetery Association (F. S. Newcomb, Pres.)	New London	1	Sept. 19	913
New London County Nurseries (W. J. Schoonman, Prop.)	New London	5	May 18	897
North-Eastern Forestry Co	Cheshire	20	Sept. 5	906
Norwich Nurseries (O. E. Ryther Prop.)	Norwich	6	Dec. 3	975
Oakland Nurseries	Manchester	5	Sept. 26	924
Palmer, L. M., Estate of	Stamford	5	Oct. 7	936
Park Gardens	Bridgeport	1	Oct. 3	931
Pequod Nursery Co	Meriden	15	Sept. 26	921
Phelps, J. Wesson	Bolton	1	Sept. 26	920
Phelps & V. T. Hammer Co., The J. W	Branford	2	Oct. 22	953
Pierson, A. N., Inc	Cromwell	35	Sept. 5	904
Platt Co., The Frank S	New Haven	1	Oct. 7	937
Pomeroy, Edwin C	Northville	1	Oct. 14	946
Purington, Mrs. C. O	Hartford	1	Oct. 9	938
Quality Seed Store	Stamford	1	Oct. 11	943
Raab, Joseph O	Ansonia	1	Oct. 25	955
Reck, Julius	Bridgeport	1	Oct. 3	930
Roehrich, W. G	Stratford	1	Sept. 20	915
Saxe & Floto	Waterbury	1	Nov. 23	973
Schleichert, F. C	Bridgeport (2)	1	Dec. 5	976
Scott, J. W	Hartford	5	Nov. 9	967
Sierman, C. H	Hartford	5	Oct. 4	933
South Wilton Nurseries	South Wilton	5	Sept. 5	903
Steck, Charles A	Bethel	1	Oct. 23	954

NURSERY FIRMS IN CONNECTICUT RECEIVING CERTIFICATES IN 1918—*Conc'd.*

Name of Firm	Address	Acreage	Certificate Issued	No. of Certificate
Stratfield Nursery Co.	Bridgeport	4	Dec. 30	980
Traendly & Schenck	Rowayton	2	Oct. 15	948
Upson, R. E.	Marion	1	Oct. 31	960
Verkade, H.	New London	1	Sept. 17	911
Vidbourne & Co., J.	Hartford	7	Oct. 1	926
Wallace, Arthur T.	Wallingford	2	Oct. 14	947
Wallingford Nurseries	Wallingford	10	Sept. 26	922
Wild, Henry	Riverside	2	Oct. 15	949
Wilson & Co., C. E.	Manchester	10	Sept. 5	905
Yale University Forest School	New Haven	1	Oct. 15	950
Young, Mrs. Nellie A.	Pine Orchard	1	Oct. 30	959
Total acreage		1556		

INSPECTION OF IMPORTED NURSERY STOCK.

As in 1917, less nursery stock was received in Connecticut in 1918 than during the preceding year. This is due, of course, to the conditions brought about by the war in Europe. There is a scarcity of labor for growing the stock especially in France and England where all available labor is directed toward the production of food or munitions. As Belgium has been occupied by German troops and many laborers deported, it is fair to assume that in Belgium, also little attention has been given to the growing of nursery stock though the exact conditions there are not known to us. In Holland, too, the war has necessitated many economic changes. It is reported that a large portion of the army has been kept mobilized. Many refugees and interned soldiers have been fed, and much relief work has been done. The growing of bulbs and nursery stock has long been an important industry in Holland, and though without doubt it is still important, it is inconceivable that it should not be seriously affected and curtailed by the war.

The shipping facilities, also have not favored the importation of foreign nursery stock into the United States. Consequently the total number of both shipments and plants brought into Connecticut has been less than half that of 1917, and shows a still greater decrease if compared with the figures for 1916. These records for the three seasons are given in the table below.

Year	Shipments	Cases	Plants
1916	291	2,102	1,998,178
1917	163	682	1,706,977
1918	73	387	830,035

Of the plants received in 1918, a large proportion consisted of Manetti rose and seedling fruit stocks.

The shipments have entered the Country under the system of permits and notices adopted a few years ago by the Federal Horticultural Board. This system is still in force, and the inspections have nearly all been made by State men at destination points within the State. Most of the inspection work was done by Messrs. Lowry and Zappe but Messrs. Davis, Walden and Britton assisted during the rush seasons. The total time necessary to make these inspections amounted to 58 days of 7½ hours each, or more than one-sixth the working time of one man for a year. The cost of this work including time and travelling expenses has amounted to about $418.87 or about two-thirds that of the preceding year, and has been paid on duly accredited vouchers by order of the State Comptroller from the appropriation for suppressing gipsy and brown-tail moths and for inspecting imported nursery stock.

The sources of this stock are given in the following table:

SOURCES OF IMPORTED NURSERY STOCK, 1917-1918.

Country	No. of Shipments	No. of Cases
Holland	33	223
France	19	97
England	13	43
Scotland	3	3
Ireland	2	2
Japan	2	17
Unknown	1	2
Total	73	387

It will be noted that none of this stock came directly from Belgium, Italy or Germany. Belgium has heretofore been a prolific source of such stock and even last year there were 56 shipments containing 234 cases, brought into Connecticut from Belgium. There has never been much nursery stock brought into Connecticut from Italy or Germany and the last shipments to arrive from each of these Countries were in the season of 1914-1915.

As three shipments were sent into other states, two refused and 73 inspected, a total of 78 shipments were reported to the Federal Horticultural Board.

Of the 73 shipments inspected, 21 shipments or 28.7 per cent. were found infested with insects or fungi some of which are pests. None, however, are known to be important pests not already found in this country. One of the most notable is the Boxwood Leaf-

Miner or Leaf Midge, *Monarthropalpus buxi* Lab. which was found in one shipment from Gouda, Holland, and in another shipment from Surrey, England. Though this appears to be the first definite record for Connecticut, the insect has been reported from Rhode Island, Philadelphia, Pa., Long Island and Westchester County, N. Y., and may at any time be found here.

Some of the insect pests found were identified in this department and some of the fungi were determined by Dr. G. P. Clinton, Botanist of this Station. Other insects and plant diseases were identified by the Bureaus of Entomology and Plant Industry respectively of the U. S. Department of Agriculture, Washington, D. C.

Details regarding the infestations are given in the following list:

Pests Found on Imported Nursery Stock, 1917-18.

21 Shipments Infested.

Insects, Etc.

Acronycta (?) sp. cocoon on Rose stock. Levavasseur & Sons, Ussy, France.

Alphitophagus bifasciatus Say. Rose stock. Stuart Low & Co., Enfield, England.

Anisodactylus binotatus Fabr. (2) Evergreens. Walter C. Slocock, Surrey, England.

Anisodactylus binotatus Fabr. (1) On moss around roses. Hugh Dickson, Ltd., Belfast, Ireland.

Centipedes on Rose stock. Louis Leroy Nurseries Co., Angers, France.

Chionaspis salicis L. On cross piece of packing box. Thos. Smith & Sons, Troon, Scotland.

Diprion cocoon, parasitized. On Rose stock. Louis Leroy Nurseries Co., Angers, France.

Diprion cocoon (probably *simile*), on Rose stock. Vincent Lebreton's Nurseries, La Pyramide-Trelaze, France.

Emphytus cinctus on Fruit Tree Stocks. E. Turbat & Co., Orleans, France.

Emphytus cinctus on Rose stock.

S. Bide & Sons, Ltd., Surrey, England; Franco-American Seedling Co., Angers, France; Franco-American Seedling Co., Nantes, France; M. Gielen, Oudenbosch, Holland; Levavasseur & Sons, Ussy, France; Louis Leroy Nurseries Co., Angers, France.

Leaf Miner on Boxwood. A. Koloos & Co., Gouda, Holland; Walter C. Slocock, Surrey, England.

Othius fulvipennis Fabr. Evergreens. Walter C. Slocock, Surrey, England.

Oyster-shell Scale on Boxwood. Ebbinge & Van Groos, Boskoop, Holland; W. Van Kleef & Sons, Boskoop, Holland.

Pontia rapae Linn. pupa on Rose stock. Vincent Lebreton's Nurseries, La Pyramide-Trelaze, France.

Soft Scale on Boxwood. Schaum & Van Tol, Boskoop, Holland.

Spider on rose stock. Louis Leroy Nurseries Co., Angers, France.

Spider's eggs on Holland plants. As. Ouwerkerk, Boskoop, Holland.

Staphylinid Beetle on Rose stock. F. J. Grootendorst & Sons, Boskoop, Holland.

Stenolophus skrimshiranus Schrank. Evergreens, Walter C. Slocock, Surrey, England.

Woolly Aphis on Apple Roots. Franco-American Seedling Co., Angers, France.

Coleopterous larva in soil around Rhododendrons. Harry Koolbergen, Boskoop, Holland.

Plant Diseases.

Crown gall on Rose stock. Levavasseur & Sons, Ussy, France; Vincent Lebreton's Nurseries, La Pyramide-Trelaze, France.

Immature fungus, possibly *Phyllosticta* sp. on Rhododendron. Vincent Lebreton's Nurseries, La Pyramide-Trelaze, France.

INSPECTION OF APIARIES.

The inspection of apiaries has been carried out as in preceding years. The work is directed by the State Entomologist, and the inspections have been made by H. W. Coley of Westport, and A. W. Yates of Hartford, on a *per diem* basis. Mr. Coley covers the four southern counties, Fairfield, New Haven, Middlesex and New London, and Mr. Yates the four northern counties, Litchfield, Hartford, Tolland and Windham.

On account of the severe winter many colonies, and in some cases entire apiaries, died. The number of colonies per apiary is therefore less than usual.

During the season, 385 apiaries, containing 2,913 colonies were inspected: in 1917 the record was 473 apiaries and 4,506 colonies. Eighty-three towns were visited as against 84 last year.

Though the number of apiaries and number of colonies inspected are less than last year, the percentage of infestation with European foul brood was considerably smaller.

In 1918, visits were made to the following towns not visited in 1917: Monroe, Wallingford, East Lyme, Bridgewater, Colebrook, Cornwall, Goshen, Litchfield, Norfolk, North Canaan, Salisbury, Sharon, Winchester, East Granby, Enfield, Suffield, Windsor Locks, Columbia, Somers, Stafford, Willington, Ashford, Chaplin, Canterbury and Scotland. All other towns where inspection, were made were visited in 1917. No inspections were made in the following towns which were visited in 1917: Bridgeport, Branford, Cheshire, Guilford, Hamden, Meriden, North Branford, Wolcott, Durham, Middletown, Portland, Lisbon, Roxbury, Thomaston, Woodbury, East Hartford, Glastonbury, Manchester, Southington, West Hart-

ford, Andover, Bolton, Brooklyn, Putnam, Windham, and Woodstock.

Apiaries were inspected for the first time in the towns of Bridgewater, Chaplin, Clinton, Columbia and Cornwall.

No inspections were made in 1918, in Middlesex County, but in all the other seven counties European foul brood was found and in the following towns: Easton, Greenwich, New Canaan, Ridgefield, Stamford, Ansonia, Derby, Madison, Prospect, Wallingford, East Lyme, New London, Old Lyme, Waterford, Bridgewater, New Hartford, Plymouth, Winchester, Bloomfield, East Granby, New Britain, Plainville, Windsor Locks, Coventry, Mansfield, Vernon and Sterling.

American foul brood was found in 1918 in Fairfield, New Haven and New London Counties and in the towns of Greenwich, Stamford, Madison, Waterford and Norwich. This disease seems to occur chiefly in the southern half of the state.

The statistics of the apiaries inspected in each of the 83 towns, in each of the seven counties in 1918, are given in the following tables, the summary occuring on page .

APIARIES INSPECTED, 1918.

Town FAIRFIELD COUNTY.	No. Apiaries Inspected	 Diseased*	No. Colonies Inspected	 Diseased*
Bethel	9	0	41	0
Danbury	1	0	21	0
Darien	2	1	42	2
Easton	2	0	81	0
Fairfield	6	0	80	0
Greenwich	13	5	87	7‡
Huntington	2	0	82	0
Monroe	5	0	70	0
New Canaan	6	2	38	2
Norwalk	8	0	92	0
Redding	5	0	48	0
Ridgefield	9	2	59	2
Stamford	13	5	125	14§
Stratford	2	0	74	0
Trumbull	1	0	68	0
Westport-Weston	8	0	73	0
Wilton	3	0	11	0
Total	95	15	1092	27

* European foul brood unless otherwise indicated.

‡ One with American foul brood.

§ Ten with European, two with American foul brood; one with sacbrood; one with bee paralysis.

New Haven County.				
Ansonia	1	1	16	2
Beacon Falls	1	0	18	0
Derby	5	1	63	2
Madison	3	1	24	4†
				6
Middlebury	2	0	25	0
Milford	2	0	69	0
Naugatuck	3	0	30	0
North Haven	4	0	32	0
Prospect	8	2	40	2
Seymour	2	0	41	0
Wallingford	6	1	49	2
Waterbury	4	0	18	0
Total	41	6	425	18
New London County.				
East Lyme	2	2	37	5
Montville	6	0	41	0
New London	2	1	38	2
Norwich	6	1	135	1†
Old Lyme	2	1	42	2
Waterford	7	1	50	35¶
Total	25	6	343	45
Litchfield County.				
Bridgewater	4	2	24	4
Colebrook	1	0	1	0
Cornwall	3	0	22	0
Goshen	2	0	1	0
Kent	8	0	47	0
Litchfield	5	0	26	0
New Hartford	2	1	26	1
New Milford	11	0	90	0
Norfolk	6	0	11	0
New Canaan	8	0	65	0
Plymouth	2	1	8	1
Salisbury	9	0	46	0
Sharon	11	0	56	0
Watertown	1	0	5	0
Winchester	10	1	49	1
Total	83	5	477	7

† All American foul brood.
¶ Five with American foul brood.

Hartford County.

Berlin	14	0	45	0
Bloomfield	7	1	158	1
Bristol	5	0	15	0
Burlington	4	0	21	0
Canton	1	0	16	0
East Granby	4	2	13	2
East Windsor	14	0	54	0
Enfield	4	0	11	0
Farmington	2	0	8	0
Hartford	7	0	59	0
New Britain	1	1	3	1
Newington	1	0	3	0
Plainville	4	1	12	1
South Windsor	6	0	10	0
Suffield	4	0	7	0
Windsor Locks	1	1	4	4
Total	79	6	439	9

Tolland County.

Columbia	2	0	2	0
Coventry	7	2	39	3
Ellington	8	0	28	0
Mansfield	6	1	38	3
Somers	8	0	17	0
Stafford	1	0	5	0
Vernon	6	1	23	1
Willington	8	0	21	0
Total	46	4	173	7

Windham County.

Ashford	1	0	5	0
Canterbury	2	0	7	0
Chaplin	2	0	15	0
Killingly	3	0	3	0
Plainfield	5	0	13	0
Pomfret	1	0	12	0
Scotland	1	0	20	0
Sterling	5	1	12	1
Windham	6	1	11	0
Total	26	2	98	1

SUMMARY.

County	No. of Towns	No. Apiaries Inspected	No. Apiaries Diseased	No. Colonies Inspected	No. Colonies Diseased
Hartford	16	79	6	439	9
Tolland	8	46	4	173	7
Fairfield	17	95	15	1,092	27
New Haven	12	41	6	425	18
Litchfield	15	83	5	477	7
New London	6	25	6	343	45
Windham	9	26	2	98	1
Middlesex	0	0	0	0	0
Total	83	395	44	3,047	114

	Apiaries	Colonies
Number inspected	395	3,047
Infested European foul brood	39	99
Per cent. infested	9.8	3.3
Infested American foul brood	4	10
Per cent. infested	1.01	.32
Pickled or sacbrood	1	1
Bee paralysis	1	1
Average number of colonies per apiary		7.8
Cost of inspection		$780.32
Average cost per apiary		1.97
Average cost per colony		.25

Records of European Foul Brood in Connecticut.

In discussing the subject of European foul brood with a bee-keeper, I remarked that the disease had probably been found in every town in the state. Afterward I wondered if this were true. Then we looked up the records, and this paper is the result.

It should be borne in mind that the appropriation for inspecting apiaries has never been sufficient to cover the cost of inspecting all apiaries each year. A small proportion only can be examined. There has been an attempt, however, to cover a somewhat different section each year in order to become familiar with the apiary conditions in the whole state. Nevertheless there are a few towns in which inspections have never been made. These are as follows: New Fairfield and Sherman, Fairfield County; East Haven and Oxford, New Haven County; Chester, Essex, Middlefield, Old Saybrook, Saybrook, and Westbrook, Middlesex County; Franklin, Lebanon, Preston and Voluntown, New London County; Washington and Warren, Litchfield County; Avon, Hartford County; Union, Tolland County; Eastford, Windham County.

Just what territory should be covered in any year, is determined largely by the inspectors, themselves, after consulting with the State Entomologist. There are always places that need visiting on account of disease conditions the preceding year. There are also many requests from beekeepers that their apiaries be examined. It is good practice, I believe, to pay special attention to the more important beekeeping centers where the industry as a whole can be most markedly benefited by the inspection work.

The following records show the names of towns in which inspections have been made during the nine years since the inspection law went into effect; that no European foul brood has ever been found by the inspectors in the towns of Brookfield and Trumbull, Fairfield County; Bethany, North Branford, North Haven, Orange, and Woodbridge, New Haven County; Clinton, Middlesex County; Groton, Ledyard, Lyme and Sprague, New London County; Canaan, Cornwall, Goshen, Morris, Roxbury, Salisbury and Woodbury, Litchfield County; Simsbury, Hartford County; Columbia, Ellington and Somers, Tolland County; Ashford, Canterbury and Chaplin, Windham County. This does not mean that the disease has never occurred in these towns.

European foul brood has been found in many towns as the following tables will show. These towns are arranged alphabetically by counties, and after the name of each town is given the year that the disease was found.

FAIRFIELD COUNTY.

Town	Year
Bethel	'10, '14, '15, '16, '17.
Bridgeport	'10, '11.
Danbury	'10, '13, '14, '15 '16.
Darien	'11, '14, '18.
Easton	'10, '11, '14.
Fairfield	'10, '11, '13, '14, '15, '17.
Greenwich	'11, '12, '18.
Huntington	'11, '17.
Monroe	'16.
New Canaan	'10, '14, '15, '17, '18.
Newtown	'16.
Norwalk	'10, '13, '17.
Redding	'10, '11.
Ridgefield	'10, '11, '14, '15, '16, '17, '18.
Stamford	'11, '12, '13, '15, '17, '18.
Stratford	'11, '13, '15.
Weston	'13, '17.
Westport	'10, '12, '13, 14, '15, '17.
Wilton	'10, '11, '14, '16.

NEW HAVEN COUNTY.

Town	Year
Ansonia	'16.
Beacon Falls	'12, '13, '14.
Branford	'12.
Cheshire	'15.
Derby	'10, '11, '13, '14, '15, '18.
Guilford	'16.
Hamden	'14, '15.
Madison	'15, '16, '17, '18.
Meriden	'12, '13, '16.
Middlebury	'15, '16, '17.
Milford	'12, '14.

Naugatuck '17.
New Haven '16.
Prospect '13, '16, '18.
Seymour '10, '11, '14.
Southbury '11, '16.
Wallingford '18.
Waterbury '17.
Wolcott '16, '17.

MIDDLESEX COUNTY.

Town Year
Cromwell '10, '12.
Durham '10.
East Haddam '10, '14, **'16.**
East Hampton '12, '13, **'14, '15.**
Haddam '14.
Killingworth '14.
Middletown '10, '15.
Old Lyme '12, '15, '18.
Portland '12.

NEW LONDON COUNTY.

Town Year
Bozrah '16.
Colchester '12, '14, '15.
East Lyme '17, '18.
Griswold '12.
Lisbon '12, '14, '15, '16, '17
Montville '14, '15, '16, '17.
New London '12, '15, '16, '17, '18.
North Stonington '15.
Norwich '12, '13, '14, '15, '17.
Salem '16.
Stonington '12, '15.
Waterford '15, '16, '17, '18.

LITCHFIELD COUNTY.

Town Year
Barkhamsted '12, '13, '15.
Bethlehem '15.
Bridgewater '18.
Colebrook '15.
Harwinton '14.
Kent '16.
Litchfield '11, '12, '13.
New Hartford '15, '18.
New Milford '17.
Norfolk '16.
North Canaan '16.
Plymouth '14, '15, '16, '17, '18.
Sharon '12.
Thomaston '13, '14, '15.
Torrington '12, '14, '15, '16.
Watertown '14, '15.
Winchester '12, '13, '14, '15.

HARTFORD COUNTY.

Town Year
Berlin '14, '15.
Bloomfield '11, '12 '13, '16, **'17, '18.**
Bristol '14, '15, '16, '17.
Burlington '13, '14.
Canton '13, '14, '15.
East Granby '14, '15, '18.
East Hartford '14.
East Windsor '14, '17.
Enfield '11, '14, '15.
Farmington '10, '12, '13, '14, **'15, '17.**
Glastonbury '14, '15, '16.
Granby '14.
Hartford '10, '11, '14.
Hartland '15.
Manchester '10, '12, '13, '14, '15, '17.
Marlboro '12.
New Britain '14, '15, '17, '18.
Newington '10.
Plainville '14, '15, '16, '17, '18.
Rocky Hill '11, '14.
Southington '14, '17.
South Windsor '12, '14, '15.
Suffield '14.
West Hartford '10, '11, '12, '13, '14, '16.
Westersfield '10, '11, '13, '15, '17.
Windsor '10.
Windsor Locks '11, '15, '18.

TOLLAND COUNTY.

Town Year
Andover '15, '16.
Bolton '13.
Coventry '13, '15, '16, '17, '18.
Hebron '12.
Mansfield '16, '18.
Stafford '14, '16.
Tolland '16.

Vernon '11, '13, '14.
Willington '11, '16.

WINDHAM COUNTY.

Town	Year
Brooklyn	'14.
Killingly	'15, '16.
Hampton	'16.
Plainfield	'16, '17.
Pomfret	'10, '11, '13, '14, '15, '17.
Putnam	'10, '11, '13, '15, '16, '17.
Scotland	'12.
Sterling	'17, '18.
Thompson	'10, '11, 17.
Windham	'12, '16, '17.
Woodstock	'10, '11, '15.

During the first year of inspection work (1910) more than 75 per cent. of all apiaries visited had some trace of European foul brood. About half of all the colonies examined were affected with the disease. The proportions have decreased consecutively until the present (1918) only about 10 per cent. of the apiaries and 3.5 per cent. of the colonies inspected have European foul brood.

PERCENTAGES OF EUROPEAN FOUL BROOD IN APIARIES INSPECTED.

Year	Diseased: European Foul Brood Apiaries, Per cent.	Colonies, Per cent.
1910	75.9	49.7
1911	51.8	27.4
1912	47.7	23.5
1913	44.4	24.5
1914	32.6	13.9
1915	26.1	10.3
1916	18.8	7.05
1917	16.7	4.86
1918	9.8	3.3

Records of American Foul Brood in Connecticut.

The present system of inspecting apiaries in Connecticut has been in vogue since the first inspection law was passed in 1909; the act did not take effect until October 1st, too late to do any work that season; consequently the first inspections were made early in the summer of 1910. Thus during nine years, a portion of the apiaries of the state have been inspected each year, the appropriation not being sufficient to inspect all apiaries annually, and permanent records are kept on 5 x 8 cards in my office. These are open to inspection during office hours.

Though European Foul Brood has been found each year, the first American Foul Brood was discovered in 1914, in the two towns of Bethlehem in Litchfield County, and Old Lyme in New London County.

In Bethlehem the disease was found in one apiary of three colonies; one colony was diseased and destroyed. No disease could be found in this apiary the following year (1915).

In Old Lyme the statistics are as follows:

One	apiary	containing	5	colonies	all	infested.
"	"	"	1	"	"	"
"	"	"	2	"	"	"
"	"	"	18	"	"	"

The first one of 5 colonies, had only one colony in 1915 and that was infested with American foul brood and European foul brood and was destroyed.

The next two were cleaned and we have no record of subsequent inspections.

In the fourth case one apiary in Old Lyme, had 18 colonies in 1914, and all were diseased with American foul brood. These were treated by Mr. Coley and when inspected on July 31 of the following year the apiary contained 45 colonies and no disease was found, though the owner had treated two colonies in the spring for American foul brood.

In 1916, two out of 45 colonies were found infested, and treated In 1917, out of 52 colonies in the apiary 6 were diseased with American foul brood. The owner agreed to treat them. In 1918 this apiary was inspected July 18, and two of the 35 colonies were found infested with European foul brood and destroyed. No American foul brood was found.

In 1915, two other apiaries in Old Lyme were found to contain American foul brood. One contained four colonies, two of which were infested. In 1916 no disease was found but in 1917, two colonies had American foul brood. In 1918, no disease was found. The other case was in an apiary of 12 colonies, four being diseased. This apiary has been inspected each year since and no disease was found.

In 1916, two apiaries in the town of Huntington contained American foul brood. Of seven colonies in one apiary, and 35 colonies in the other, one colony in each was diseased with American foul brood. In the former, this disease was not detected the following year (1917) and in the other, apparently no inspection has been made since.

One colony in an apiary of 38 in the town of Ridgefield was found diseased with American foul brood in 1916, and was destroyed. The entire apiary appeared healthy when inspected in 1918.

One colony in an apiary of 18 at East Hampton (formerly Chatham) was found diseased with American foul brood in 1916. The owner promised to give treatment but we have no subsequent record of the condition of the apiary.

In 1917, American foul brood was found only at Old Lyme in the cases which I have just described.

In 1918, however, it was found in one apiary in each of the towns of Greenwich, Stamford, Madison, Waterford, and Norwich. In Greenwich one apiary of four colonies, had one diseased; in Stamford, 45 colonies, two diseased; in Madison, 18 colonies, four diseased; in Waterford, 41 colonies, two diseased; in Norwich, 96 colonies, one diseased.

Thus it will be seen that American foul brood has been present in the following towns and counties in Connecticut:

County	Town	Year
Fairfield	Greenwich	1918
	Huntington	1916
	Ridgefield	1916
	Stamford	1918
New Haven	Madison	1918
Middlesex	East Hampton	1916
New London	Old Lyme	1914, 1915, 1916, 1917
	Waterford	1918
	Norwich	1918
Litchfield	Bethlehem	1914

Percentages of American foul brood infestation of the bees examined each year are given in the table below:

Year	Percentage of Infestation.	
	Apiaries	Colonies
1910	0	0
1911	0	0
1912	0	0
1913	0	0
1914	1.07	.7
1915	.8	.18
1916	1.07	.15
1917	.42	.17
1918	1.01	.32

SUPPRESSING THE GIPSY AND BROWN-TAIL MOTHS IN 1918.

By W. E. Britton, I. W. Davis and J. T. Ashworth.

Introduction.

This work has been conducted in about the same manner as in preceding years. Except that on account of the war, labor has become so scarce that it has been necessary to rely more upon spraying and to curtail somewhat the scouting operations. Where possible men have been employed throughout the year, either by the State or by the Federal forces. These men served as scouts during the scouting season and were all utilized on spraying work from May 17 to June 29.

As in former years this work has been carried on in co-operation with the Federal Bureau of Entomology. This co-operation has been most satisfactory and we wish to express our thanks to Mr. A. F. Burgess, in charge of the Federal work and Mr. L. H. Worthley who has had supervision of the field work. Both have shown every inclination to assist us in controlling the gipsy moth in Connecticut.

Since the publication of the report of the work done last year, seven new towns have been found slightly infested making in all 29 towns in the infested area. None of these are infested to a degree sufficient to cause noticeable injury to the foliage of trees, and most persons know that the gipsy moth is present only because they see the men at work in the scouting and spraying operations.

Men Entering the Service in 1918.

Mr. Davis was granted a leave of absence from July 1st, and enlisted in the U. S. Marine Corps for the duration of the war. Altogether 13 employees have entered the service, the following being in addition to the list printed in the report for 1917, page 247:

Irving W. Davis	Marine Corps
Arthur W. Bradley	Cavalry
Waldo P. Colvin	Limited Service
Richard Newton	Artillery
Raymond Smith	Brown University Officer's School

New Equipment.

On account of the expense and difficulty in obtaining teams to cart poison and hose during the spraying season, it was decided to use the Ford car for this purpose and a truck or "delivery" body was procured for it. This necessitated another machine for supervision and transporting men, and a used Buick six cylinder touring car was purchased in the spring. This car has been used on the work since with entire satisfaction.

Additional spraying equipment has been obtained in the purchase of an automobile truck power sprayer designed and constructed for spraying woodland trees. This machine has a carrying capacity of two and one-half tons, is fitted with a Continental four cylinder motor, a Fitzhenry-Guptill pump driven by the propelling motor, a 400 gallon tank, 36 inch solid tires with 4 inch face front, 6 inch rear. The pump and tank are readily removed and the truck used for general transportation purposes. This outfit is shown on plate XXII, a. Sixteen hundred feet of 1½ inch fire hose and 75 feet of suction hose were also purchased during the year.

Labor and Board.

On account of the shortage of labor, and particularly because of the need of men in military service and in making munitions, it is difficult to obtain and keep men in the field. As wages in munitions factories are very much higher than we have been paying, there is a temptation for the men to leave and go into the shops. In fact it is difficult at the best to obtain the right sort of men for scouts. They should be young men in good health or they are not able to walk long distances, climb trees, and be on their feet all day. Above all they must be reliable. They must have good habits, be dignified, and courteous to property owners and residents. They must have good eyes and always be on the alert. They must also have some judgment about handling an infestation.

The best men for such work are young men raised in the country, who live out of doors. Such men will hesitate and often refuse to go into factories even though greater wages may be obtained there. Consequently the men now employed are for the most part of this character. Nevertheless it has been necessary to increase wages somewhat above the amounts paid before the war. The policy has been to start a man on the minimum wage and to raise him as soon as he has acquired the proper experience and training if he shows

an adequate degree of interest, adaptability and efficiency in his work. Another great difficulty is in finding boarding places for the men. In some towns there are no hotels or boarding houses and it is impossible to find board in private families unless at a price that is prohibitive.

On account of this great difficulty of finding suitable boarding places, the men are often obliged to board in an adjoining town. To walk back and forth is too much to expect, especially when they are on their feet practically all day. Consequently we have adopted the practice of transporting the crews from their boarding place to their work, especially in the towns where board cannot be found near at hand. Each crew is taken out in the morning and brought back at night. For this purpose the motor cars are a necessity.

SPRAYING.

As has already been mentioned on account of the rather large area infested and the price and shortage of labor, it has seemed wise to curtail somewhat the scouting operations and to place more dependence upon spraying as a means of control. This change in policy requires additional apparatus, and as mentioned above a new automobile truck power sprayer was purchased for this work. The horse-drawn power sprayer is still in serviceable condition and was used and will continue to be used in the thickly infested towns like Thompson and Putnam where the infestations are not far apart. It would take several of these, however, to do all the spraying in the whole 29 towns, and where it is necessary to go ten or perhaps twenty miles from one infestation to another, much time is consumed *en route.* Moreover it is becoming increasingly difficult to hire horses and drivers for such outfits.

The auto truck sprayers, do not require horses, can be driven by qualified employees, will cover the distances at the rate of ten miles per hour, and in stormy weather do not incur expenses for board of team.

During 1918, we used two horse-drawn outfits and two automobile truck outfits one of each being furnished by the Federal authorities. The Federal men sprayed the infestations in the towns of Eastford, Windham, Hampton, Mansfield, Plainfield, Scotland, Griswold, Lisbon, Norwich, and Ledyard, and with their horse-drawn outfit helped spray the infestations in Thompson. The remaining work in Thompson and that done in Putnam, Woodstock,

Pomfret, Brooklyn, and Killingly was done by State forces. Altogether 392 separate colonies or infestations were treated by spraying. The Federal men operated their auto-truck sprayer, but the State furnished men for the Federal horse-drawn outfit.

New Towns Infested.

As in former years Federal men have scouted the towns along the outer margin of the infested area, and the State funds have been expended in the more thickly infested portion of the territory.

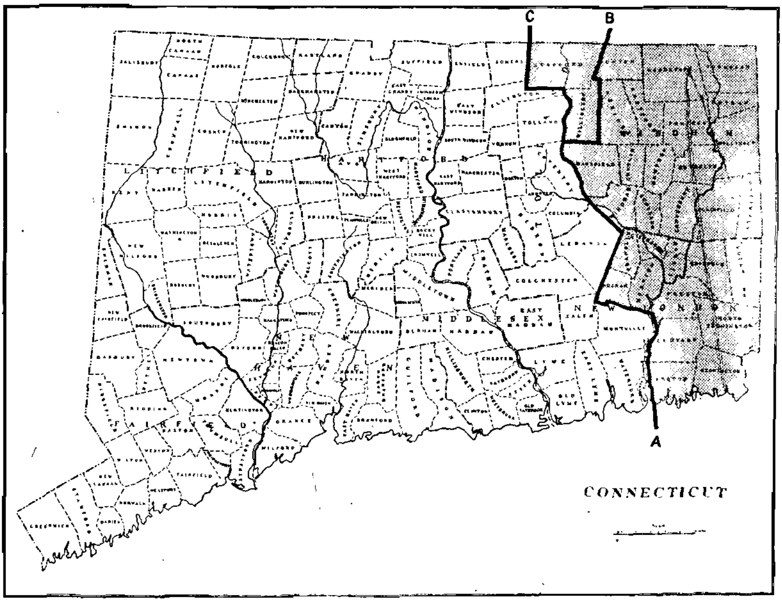

Figure 7. Map of Connecticut showing areas infested by gipsy and brown-tail moths. All territory east of the line A B is quarantined on account of the gipsy moth; territory east of the line A C is quarantined because of brown-tail moth.

As a result of scouting by the Federal men, seven additional towns were found to be slightly infested, namely, Union, Windham, Franklin, Bozrah, Norwich, Preston and Ledyard. The present infested area containing 29 towns, 617,124 acres or 964.25 square miles, is shown on the map, figure 7.

Parasites.

A full account of the parasites liberated and recovered in Connecticut was given in the Report of this Station for 1917, page 249.

There is little to be added here. Some of the parasites have been on the increase and no doubt have helped to check the pest. During 1918, in one section each of the towns of Putnam, Thompson and Plainfield the men observed *Calosoma* beetles devouring gipsy caterpillars. Three colonies of *Anastatus bifasciatus* Fonsc. were liberated in different sections of the town of Eastford.

During 1918, according to Mr. Burgess, the egg parasite, *Anastatus bifasciatus* Fonsc., was liberated in Connecticut towns as follows:

Town	No. of Colonies
Eastford	3
Putnam	31
Mansfield	1
Hampton	3
Brooklyn	3
Killingly	3
*Scotland	1
*Plainfield	4
*Sterling	2
*Griswold	2
*Voluntown	1
Total	54

This parasite was recovered in 1918 for the first time in Connecticut at Eastford.

Details of Gipsy Moth Work by Towns.

The following pages give a detailed account of the work done in each of the infested towns:

Thompson—275 Infestations—7,255 Egg-clusters.

As in preceding years, Thompson continues to be the most thickly infested town in the state. There were not as many large infestations, however, as we had reason to expect. There were many singles, which were creosoted and the trees marked, which were not counted as separate colonies as in preceding years. This is responsible for the reduction in the number of infestations from 518 in 1917 to 275 in 1918. Several large colonies of former years had evidently been entirely cleaned up. All available data point to a very successful spraying season in 1917.

* Liberated in these towns for the first time.

During the scouting of 1916-1917, the eastern portion of the town was covered first, and by the time the western part was reached, winter had arrived and the snow hindered greatly. Consequently the following year the western portion was covered first, and most of the town had been finished before winter really set in.

The Federal forces aided us by the loan of a complete spraying outfit, and with this help we were able to spray a total of 149 colonies in Thompson. The results of spraying last year in the Brandy Hill district, were apparent in the decrease in the number of infestations in 1917-18.

Owing to the early hatch and the lack of labor none of the trees were banded around the infestations in Thompson in 1918, although a number of woodland infestations were chopped and cleaned out and the brush burned during the preceding winter. After the spraying season was over, the men were sent around to the infestations, and the conditions as regards larvae were carefully noted at both sprayed and unsprayed colonies. All larvae found were destroyed and all colonies showing larvae were visited every two or three days until the men took their vacation the first of August.

Some of the woodland regions have already been examined this Fall and no large infestations have been found.

Woodstock—16 infestations—1,057 egg-clusters.

Last year Woodstock was scouted only as far west as the road marked D on our blue print map thus covering about two-thirds of the town—the eastern portion, including the villages of East Woodstock, West Woodstock, North Woodstock, South Woodstock, and Woodstock Hill. The remainder or western third consisting mostly of wooded area was not finished on account of a shortage of labor and the early hatching of the eggs (May 2d). As in the preceding year South Woodstock was the most thickly infested portion, although there were colonies scattered over the entire eastern part of the town. The largest infestation, 116 egg-clusters was located on land owned by Mr. Frank Tripp.

As was the case in Thompson no banding of trees was done, but 30 of the largest infestations were sprayed with lead arsenate. After the spraying season was over the men visited these infestations and succeeded in finding only nine larvae, which they destroyed.

Owing to its large area, abundance of apple trees, and the difficulty of obtaining board for the men the town of Woodstock has always been difficult to cover in the scouting work. The western portion of the town not covered last year has just been gone over this fall and several infestations found in the southern portion. As in Thompson single egg-clusters were not counted as infestations.

Putnam—98 infestations—2,787 egg-clusters.

This is also a part of the thickly infested area of the State. Several large colonies were found but with few exceptions these were in the woodland. The exceptions were old apple orchards where the egg-clusters were hidden in hollow limbs, difficult to find. The largest infestation (125 egg-clusters) was on land owned by Mr. Jenner on the road running north from East Putnam Four Corners near the Thompson line. As in Thompson and Woodstock single egg-clusters were not counted as separate infestations, and the trees were not banded. The horse-drawn sprayer was used in Putnam and 44 of the largest infestations were sprayed. After the spraying season was over, the men hunted for larvae around the infestations and destroyed 313 in the town. In one section of the town *Calosoma* beetles were observed feeding upon gipsy moth larvae.

Pomfret—41 infestations—1,042 egg-clusters.

During the war, much timber has been cut in Pomfret, and occasionally the inspectors reported that egg-clusters had been found on wood coming from some "set-up" back in the hills. The town was scouted in mid-winter and although scattered infestations occurred in all portions of its area, no very large colonies were found, the largest being a woodland infestation of 144 egg-clusters, on the west side of the road known as Wolf Den Drive. If any portion of the town is more thickly infested than another it is the northeastern part near the Putnam and Woodstock boundaries. As in Thompson, Woodstock and Putnam the trees were not banded and single egg-clusters were not counted as separate infestations. Of the 41 infestations, 33 were sprayed, and later 411 larvae were found and destroyed. The new automobile truck power sprayer was used here, and proved efficient and satisfactory. Recent scouting shows fewer infestations than last year, which indicates that the work was effective.

Union—2 infestations—5 egg-clusters.

This town has a large area, sparsely settled, and is difficult to cover in the scouting operations. The work was done by the Federal men, and two small infestations, of two and three egg-clusters respectively were discovered in the southeastern portion of the town. Here the trees were banded around each infestation. No spraying was done. It is believed that the gipsy moth has been eradicated from these infestations.

Ashford—5 infestations—44 egg-clusters.

Ashford was also scouted by Federal scouts and five infestations found, all in the eastern and southeastern part of the town. The largest colony contained 16 egg-clusters and was on land owned by Mr. Joseph McQuad near the Chaplin line. Four of the five colonies were banded, but on account of shortage of men, these infestations were not patrolled afterwards. No spraying was done in Ashford.

Eastford—33 infestations—548 egg-clusters.

Eastford was scouted by Federal men and 33 infestations were found, most of which are in the northeastern corner near Woodstock and Pomfret. Of the 548 egg-clusters, 369 were in three colonies, the largest containing 225 egg-clusters being in woodland owned by Mr. Andrew Chilkoth about a mile northeast of Eastford Post Office. In early spring State men banded the trees with "Raupenleim" around 17 of the largest infestations. One infestation was sprayed by the Federal auto-truck sprayer, and in the late winter three colonies of the egg-parasite, *Anastatus bifasciatus* Fonsc., were liberated in different sections of the town.

Chaplin—9 infestations—45 egg-clusters.

The results of scouting in Chaplin by the Federal men was the discovery of nine infestations divided into three groups—one in the northeastern, one in the southeastern, and one in the middle western portion of the town. The largest colony contained 14 egg-clusters, and was located on apple trees owned by Mrs. Anna Kinsell about one mile southwest of Chaplin Post Office. Of the nine infestations, six were banded with "Raupenleim" and none were sprayed.

Hampton—33 infestations—336 egg-clusters.

The infestations are scattered over all parts of the town, though most of them were grouped along an east and west line running

across the center of the town. The scouting was done by Federal men, and one infestation was sprayed by them. The largest colony contained 52 egg-clusters, and was on land owned by Mr. Martin Navin, Jr., near the Chaplin line. Two other colonies of 45 egg-clusters each were found, one on land owned by Mr. J. L. Goodwin, about one and one-half miles due east from the colony mentioned above, and the other on land owned by Mr. J. M. Woodward in the northeastern part of the town.

Brooklyn—60 infestations—876 egg-clusters.

Brooklyn was scouted by the State men and 60 infestations found, about half occurring in the northeastern portion of the town. A large woodland colony of 86 egg-clusters was found on the summit of Tatnic Hill, and this was cleaned of brush, etc. (3½ acres) by men working stormy days. This colony was sprayed in summer with our new auto-truck sprayer and 1,800 feet of hose had to be laid to reach all parts of it. Recent scouting shows only nine new egg-clusters where 86 were found last year. In all 43 infestations were sprayed in Brooklyn, and the men found and destroyed 511 larvae. Here as in Thompson, Woodstock, Putnam and Pomfret, single egg-clusters were not counted as separate infestations, though included in the total number of egg-clusters.

Killingly—62 infestations—1,411 egg-clusters.

Killingly was scouted by the state men and 62 infestations and 1,411 egg-clusters were found, the largest colony containing 107 egg-clusters occurring on apple and oak trees on land owned by Mr. J. T. French in East Killingly. Though the infestations are distributed over the town, the only portions thickly infested are the northern portion next to Putnam and the eastern portion next to Rhode Island. No banding was done in Killingly, but 40 of the largest infestations were sprayed with lead arsenate, both the horse-drawn sprayer and the new auto truck sprayer being used. While patrolling the infestations, the men destroyed 236 larvae. A few of the woodland colonies have been examined this fall and few egg-clusters were found.

Mansfield—2 infestations—86 egg-clusters.

Two infestations were found in Mansfield, both in the northern part of the town. One of 84 egg-clusters was on land owned by Mr. Adam Ciba, and the other of 2 egg-clusters was on land of Mr. B. E.

Taintor. The larger of these infestations was banded by the State men and sprayed by the Federal men. The latter did the scouting in the town.

Windham—2 infestations—34 egg-clusters.

Both of the two infestations in Windham were in the northeastern part of the town. One, of 14 egg-clusters was on large white oaks along the railroad near the Chaplin line on land of Mr. Edward Hall; the other contained 20 egg-clusters, and was located about one and one-half miles south of this point on land owned by Mr. W. A. Standish. Thirty-two and forty, respectively, bands of "Raupenleim" were applied by the State men. Both colonies were sprayed and the entire town scouted by the Federal employees.

Scotland—7 infestations—136 egg-clusters.

The infestations in Scotland are extended along the line of the State road running east and west across the center of the town. Five of these colonies are on the State road, the largest of 80 egg-clusters being on land owned by Mr. Byron E. Wilson. Four colonies were banded by State men and sprayed by Federal men.

Canterbury—37 infestations—508 egg-clusters.

This town was scouted by State men who were under the direct supervision of Federal foremen. Canterbury covers about 36 square miles and is one of the towns which have been found infested for several years, but the finding of 37 colonies was a heavier infestation than had been anticipated.

These colonies were scattered throughout the town, the northwestern corner being the most thickly infested. Six colonies were found which contained 40 or more egg-clusters, the largest of 99 egg-clusters being in an orchard of Mr. Charles Moffit about two miles southwest of Canterbury post office. Several colonies were cleaned of brush, etc., on stormy days but none of the infestations were banded or sprayed.

Plainfield—68 infestations—954 egg-clusters.

Previous to 1917 only one locality had been found infested in this town and that in the western portion near the Quinebaug River. In fact so few evidences of the gipsy moth had been observed in this town that during 1916 only a small portion was scouted. This past winter therefore it was deemed necessary to scout the entire town, with the result that 68 infestations scattered throughout the entire area were located.

Many of these contained only a single egg-cluster each but there were several large colonies the largest containing 80 egg-clusters; this was on land owned by Mr. James Dawning.

During the summer three of the largest infestations were sprayed by the Federal men and the patrolling which was done resulted in the finding of 182 larvae.

Sterling—35 infestations—412 egg-clusters.

This town has been lightly infested for the past four years, but this past winter there was a large increase in both the colonies and in the number of egg-clusters found. About three-fourths of the infestations were in the northern half of the town, and 31 of them were in apple-orchards. The largest colony contained 47 egg-clusters and was located on apple trees owned by Mr. Carl Waas near the Rhode Island line about two miles north of the railroad. None of the infestations were sprayed or banded by State or Federal employees, but owners were advised to spray their trees in order to aid in controlling the pest.

Franklin—2 infestations—6 egg-clusters.

Franklin was scouted for the first time in the winter of 1917-18, and the result was the finding of two colonies of the gipsy moth, one containing two and the other four egg-clusters. These were both in the southern part of the town and both were located in orchards which made them easy to control. These were banded with "Raupenleim" but it was not thought necessary to spray either infestation.

Sprague—1 infestation—1 egg-cluster.

Only a single egg-cluster could be found in the scouting operations conducted by the Federal men in the town of Sprague. As this town has been considered infested for two or three years, it is remarkable that the pest was not more in evidence.

Lisbon—2 infestations—18 egg-clusters.

Lisbon was again found infested in 1918, nothing having been found since 1914. One colony containing 16 egg-clusters, was on land owned by Mr. Wade in the northwest corner of the town near the Canterbury line. The other was on land owned by Mrs. A. F. Strong on a dead end road in center of town about one and one-fourth miles south of railroad. The former was sprayed by the

Griswold—13 infestations—234 egg-clusters.

The result of the winter's scouting in Griswold was the finding of 13 gipsy moth colonies. A majority of these were found in the northeastern section of the town near the Plainfield and Voluntown lines. This group of infestations were all small and the two large colonies found were in other parts of the town. One of these contained 34 and the other 77 egg-clusters, but both were favorable for control work as one was in a roadside oak and the other in an old apple-tree. All infestations were banded and during June, four of the most serious were sprayed.

Voluntown—9 infestations—54 egg-clusters.

Voluntown was only partially covered the preceding year and four single egg-clusters found. In fact only slight infestations were ever found there. It was thought best to go over the entire area in 1917-18 and this was done by the Federal men, with the result that nine infestations were discovered. These were all in the northern portion of the town and with one exception were all small colonies. This particular colony contained 30 egg-clusters and was found in an old apple-tree near the Rhode Island line. This infestation was banded as were others in this town, but no spraying was thought necessary.

Bozrah—2 infestations—19 egg-clusters.

The Federal men scouted Bozrah and for the first time found it infested. Two colonies were discovered, both near the Norwich line, the larger, containing 17 egg-clusters being in a group of roadside maples. Both infestations were banded but neither one was sprayed.

Norwich—6 infestations—128 egg-clusters.

This town was scouted some four years ago but as no traces of the gipsy moth were found it was not examined again until last year. The result was the finding of six colonies placing Norwich in the list of infested towns. These were well separated and extended in a line from north to south through the town.

The largest colony which contained 96 egg-clusters was located in the center of the town on land owned by Mr. Thomas Beetham. This colony was sprayed early in the season as was also one other in Norwich. All colonies were banded but it was impossible to do any patrol work.

Preston—5 infestations—128 egg-clusters.

Preston had not been scouted for two years, and when the Federal men finished the scouting this year five infestations had been

discovered. These were widely separated and contained two rather large colonies, one of 72 and the other of 39 egg-clusters. The former was in an old orchard about half-way between Preston City and Norwich while the latter was located in a pasture near the North Stonington town line. All of the infestations were banded but there was no spraying done in this town.

Montville—0 infestations—0 egg-clusters.

The roads in the eastern part of the town were scouted but no infestations were found.

Ledyard—4 infestations—102 egg-clusters.

In 1917-18, this town was found infested for the first time. Though the four colonies were well scattered, the most important one containing 90 egg-clusters was found in an old apple-orchard on the old Stoddard farm near Stoddard's wharf in the western portion of the town. This orchard though sprayed by the Federal men had considerable undergrowth on one margin and the condition of the nearby roads made spraying difficult.

Both "Raupenleim" and tanglefoot were used in the banding of the colonies in this town but labor conditions made proper patrolling impossible.

North Stonington—6 infestations—55 egg-clusters.

The six colonies found in North Stonington were widely separated, the most serious being a little south of Pendleton Hill, on high elevation scattered through a section of woodland. Several broken stone walls and much undergrowth made this colony a difficult one to treat. All infestations were banded but no spraying was done in North Stonington.

Groton—1 infestation—2 egg-clusters.

During the winter of 1916-17 several spruce trees were shipped to the Plant Estate, from the heavily infested district in Massachusetts. At the time they were sent they were covered with ice and snow and it was impossible for the inspection to be really thorough and accordingly these trees were given special attention this year. The result was the *finding of two* egg-clusters, both small and both found on the same tree, a spruce. These were treated in the usual manner and as the nearby growth is well cared for and is not favorable for food plants it is doubtful if there will be a recurrence of this pest in this vicinity. No spraying or banding was done. The

entire town was subsequently scouted by the Federal men but no other infestations were found.

Stonington—4 infestations—120 egg-clusters.

As a result of the winter's scouting by Federal men, four gipsy moth colonies were found, all being located in the eastern portion of the town near the Rhode Island boundary. The largest colony was found in the Pawcatuck section of Westerly and this together with the other Stonington infestations was banded early in the season.

There was no spraying done in this town.

Statistics of Infestations.

The following table summarizes the work by towns:

Towns	No. of Infestations	No. of Egg-clusters Destroyed	No. of Bands Applied	No. of Infestations Sprayed	No. of Larvae Destroyed
Thompson	275	7,255	0	149	1,190
Woodstock	46	1,057	0	30	9
Putnam	98	2,787	0	44	313
Pomfret	41	1,042	0	66	411
Eastford	33	548	490	1	0
Ashford	5	44	147	0	0
Killingly	62	1,411	0	40	236
Brooklyn	60	876	0	43	511
Hampton	33	336	0	1	0
Chaplin	9	45	183	0	0
Mansfield	2	86	7	1	0
Sterling	35	412	496	0	0
Plainfield	68	954	346	3	182
Canterbury	37	508	0	0	0
Scotland	7	136	80	4	0
Voluntown	9	54	327	0	0
Griswold	13	234	460	4	0
Lisbon	2	18	0	1	0
Sprague	1	1	22	0	0
North Stonington	6	55	68	0	0
Stonington	4	120	96	0	0
Groton	1	2	0	0	0
Union	2	4	0	0	0
Windham	2	34	72	2	0
Preston	5	128	105	0	0
Norwich	6	128	206	2	0
Ledyard	4	102	48	1	0
Bozrah	2	10	23	0	0
Franklin	2	6	122	0	0
Totals	870	18,393	3,298	392	2,852

Some of the bands were of tree tanglefoot, and some of "Raupenleim." The "Raupenleim" was applied with a hand apparatus holding about three pints of material, and called a gun. At first an attempt was made to record the number of guns instead of the number of bands but this was discontinued. Thus in Eastford 23 guns supplied material for 490 bands. In Union four guns were applied, approximately 100 bands.

In Thompson, Putnam, Woodstock, Pomfret, Brooklyn and Killingly, the single egg-cluster infestations were not recorded as separate infestations but were included among the egg-clusters destroyed.

Brown-Tail Moth Work.

The brown-tail moth has been conspicuous by its absence during the past year, and control measures were unnecessary. In 1915, the area quarantined by the Federal Horticultural Board included Granby, Simsbury, Bloomfield, West Hartford, Old Saybrook and all towns east of the Connecticut River, a total of 71 towns. In 1917 the boundary of the quarantine was changed, thus releasing eight towns, namely: Granby, West Hartford, Hartford, East Hartford, Manchester, Glastonbury, Portland and East Haddam. Further changes were made in 1918, which released from quarantine the following: Suffield, Enfield, Somers, East Granby, Windsor Locks, East Windsor, Ellington, Simsbury, Bloomfield, South Windsor, Vernon, Tolland, Bolton, Coventry, Andover, Columbia, Chatham, Marlboro, Hebron, Lebanon, Colchester, Salem, Montville, Old Saybrook, Lyme, Old Lyme, East Lyme, Waterford, and New London, 29 towns. This change was based upon an examination of the territory from Long Island Sound northward to the Massachusetts line, by the Federal scouts. The entire infested area was covered somewhat hastily by the combined efforts of State and Federal men and only one winter nest was discovered—and that in Woodstock. A nest was reported from Stonington but this report was not verified.

Appropriation and Expenditures.

The General Assembly of 1917 appropriated $40,000.00 for the biennial period ending September 30, 1918, for suppressing the gipsy moth and the brown-tail moth and for inspecting imported nursery stock. As the brown-tail moth has largely disappeared, it has not seemed necessary to expend much money in combating it. The shipping and other conditions brought about by the war have

reduced the quantity of imported nursery stock entering Connecticut, so the cost of inspecting it has been considerably less than the average for the past few years, or about $363.66 altogether for the year. Consequently nearly all of the appropriation thus far expended has been for gipsy moth work. On account of the need for more spraying apparatus and equipment a new auto-truck power sprayer was purchased and somewhat more than half of the appropriation was expended during the year just ended. Nevertheless this outfit will last for several years, so its cost will not need to be duplicated in 1919.

FINANCIAL STATEMENT.

Appropriation for biennial period ending Sept. 30, 1917	$21,000.00	
Amount expended, year ending Sept. 30, 1916	13,027.67	
Balance		$7,972.33
Additional appropriations (Deficiency)		3,000.00
		$10,972.33
Amount expended, year ending Sept. 30, 1917		10,573.38
Balance		$ 398.95
Appropriation for biennial period ending Sept. 30, 1919	$40,000.00	
Amount expended, year ending Sept. 30, 1918	22,644.18	
Balance	$17,355.82	

CLASSIFIED EXPENDITURES, YEAR ENDING SEPT. 30, 1918.

Salaries and wages:

I. W. Davis	$1,125.00	
J. T. Ashworth	1,170.00	
J. A. McEvoy	1,010.58	
F. C. Rich	739.84	
K. Buffington	761.02	
R. E. Smith	611.68	
R. V. Harris	651.92	
W. P. Colvin	619.20	
D. LaBelle	487.44	
E. A. Smith	419.52	
P. H. Shea	405.20	
H. Bodo	428.48	
T. R. Ward	375.54	
W. G. Greene	320.10	
Other labor	2,565.64	
		$11,601.18

Printing and Illustration	$ 4.98
Postage	.23.43
Telegraph and Telephone	59.86
Office Supplies	12.40
Express, freight and cartage	187.97
Machinery, tools, and supplies, including gasoline	8,357.74
Insurance	323.04
Rental and storage	233.50
Travelling expenses	260.77
Automobile tires and repairs	644.51
Rebate to towns	66.50
Inspection of imported nursery stock	363.66
Miscellaneous	414.66
Total	$22,644.18

State Finance Board Visits Stripped Woodland in Massachusetts.

Early in the season Mr. Davis arranged with members of the State Finance Board to make a trip into Massachusetts to see some of the damage done to vegetation by the caterpillars of the gipsy moth. Inasmuch as no stripping has as yet been noticeable in Connecticut: appropriations are asked for at each session of the General Assembly, and as the Finance Board goes over such matters prior to the sitting of the General Assembly, and acts conjointly with the Committee on Appropriations, such a trip seemed advisable. Consequently the trip was arranged for July 12th, 1918, but as Mr. Davis enlisted in military service prior to that date he was not present to conduct the others to the defoliated woodland.

The members gathered at Putnam Thursday evening July 11, and started early the following morning in the automobiles used in the gipsy moth work. One car was driven by Mr. Ashworth and the other by Mr. Rich. The following made up the party: Robert V. Magee, John Wadhams, State Board of Finance; Senator E. S. Boyd, Edward F. Hall, Frank E. Morgan, and John G. Wightman, Committee on Appropriations; Walter O. Filley, State Forester; W. E. Britton, State Entomologist; and Messrs. Ashworth and Rich of the gipsy moth force—ten in all.

The route led through Chepachet and Providence, R. I., Fall River, New Bedford, Fair Haven to Marion, Mass., where a luncheon had been arranged, the occasion being the meeting of the Massachusetts Tree Wardens' Association. After luncheon the

Connecticut party was escorted by Mr. A. F. Burgess of the Federal Bureau of Entomology to a piece of woodland northeast of Marion and probably in the town of Wareham where several acres of native tree growth had been stripped of leaves as shown in the accompanying photographs on plates XXII, b, and XXIII.

The entire trip of 182 miles was made without any unfavorable incident, not even a tire puncture, and the party reached Putnam at seven o'clock in the evening. The members expressed themselves as being well repaid in terms of information gained, for making the trip.

Future Needs.

The Connecticut area now infested by the gipsy moth is not an isolated colony but is on the southwestern edge of the large infestation covering the whole of Rhode Island, the eastern two-thirds of Massachusetts, the southern two-thirds of New Hampshire and the southwestern portion of Maine. Extermination, though perhaps not impossible, is extremely improbable with the appropriations that are apt to be made for such work.

The increase in the cost of all materials, and especially of labor, has rendered any given appropriation arranged on a pre-war basis, inadequate. It is necessary to increase the wages of the men from time to time as they gain in efficiency and experience. Most of them could now earn far more in other lines of work. Certain qualifications and training are essential in good scouts, and at present there is little competition. Moreover, all materials and supplies have gone up in price and, in order to do the essential work, it takes considerably more money than a few years ago.

There has not been an appropriation large enough, since the summer wind spread of 1913, to adequately scout all the territory. Hundreds of acres of woodland have never been thoroughly examined either by the State or Federal Scouts. It is possible, therefore, that additional and undiscovered infestations now exist in some of the unexamined woodland areas, and that the pest is increasing there soon to break forth and spread to adjacent territory. Connecticut has been extremely fortunate in discovering and checking the pest so soon after it gained a foothold in the State, but the successful work already accomplished would not have been possible except through the hearty co-operation of the Federal Bureau of Entomology, which has expended in Connecticut each year an amount approximating that expended by the State and during the

past year has expended about $15,000. The policy of the Federal Bureau is to help those states which try to help themselves.

To give the gipsy moth suppression work its greatest possible measure of effectiveness, larger appropriations must be provided for it, and for the coming biennial period an appropriation of $80,000 has been requested. In 1917, $60,000 was requested and $40,000 granted. The increase in the number of towns infested, means that more men will have to be employed to scout these towns, and more men and more spraying apparatus will be required to spray the infestations. Even if no more towns become infested and $80,000 is appropriated $40,000 per year will not be enough to do the work. There are 617,124 acres or 964.25 square miles in the infested towns. Thus we have nearly 1,000 square miles of territory to cover each year with $40,000 which means only a little over $40.00 per square mile. Even if the Federal Bureau assists by expending a like sum $80.00 per square mile will not begin to adequately suppress this pest in a thickly infested region. It goes without saying that all of this territory will soon become thickly infested if adequate provision is not made for holding the pest in check.

RECORD OF TREATMENTS IN AN ATTEMPT TO CONTROL THE STRIPED CUCUMBER BEETLE.

Diabrotica vittata Fabr.

BY W. E. BRITTON AND M. P. ZAPPE.

This work is in continuation of experiments and observations begun several years ago to ascertain the principal insects attacking cucurbitaceous plants in Connecticut, and how to control them (See Reports of this Station, 1908, page 805; 1916, page 116; 1917, page 262).

A half acre of land at the Station farm at Mount Carmel, was devoted to this purpose and was planted to Hubbard squashes 18 rows, Winter Luxury pumpkins 9 rows, Davis' Perfect cucumber 3 rows, Osage muskmelon, 1 row, on May 23, 27, and 28. As soon as the plants appeared above ground the squashes, pumpkins and cucumbers were attacked by the beetles. The melons were almost free from them. The treatments were applied on June 6, 7, and 8. There were many beetles present especially on the squashes and pumpkins. The materials used, how applied, kind of plants, effectiveness and injury to plants are all given in the following table:

Treatment.	How applied.	Date.	Kind of Plants.	Effectiveness.	Injury to Plants.
Lead Arsenate	Covered leaves with dry powder	June 6, 1918	Squash, 3 rows	Few beetles	None
Land Plaster	Covered leaves with dry powder	June 6, 1918	Squash, 3 rows	Few beetles	None
Ground Limestone	Covered leaves with dry powder	June 6, 1918	Squash, 3 rows	Beetles present	None
Dry Bordeaux	Covered leaves with dry powder	June 7, 1918	Squash, 1½ rows	Treatment washed off that night. Many beetles	None
Dry Bordeaux	Covered leaves with dry powder, 2 applications	June 7 & 8, 1918	Squash, 1½ rows	No beetles	None
Commercial lime-sulphur	Sprayed	June 8, 1918	Squash, 3 rows	Many beetles	None
Laurel green and air slaked lime } equal parts	Dry powder on leaves	June 8, 1918	Squash, 3 rows	Very few beetles	Leaves burned slightly
Fish oil and sawdust	Sprinkled around plants	June 8, 1918	Pumpkins, 1 row	Only 8 beetles on row	None
Sulphur and lead arsenate equal parts	Dry on leaves	June 8, 1918	Pumpkins, 2 rows	Only 2 beetles on 2 rows	None
Laurel green 1 oz., air slaked lime 1 oz., molasses ¼ pt., water 1 gallon	Sprayed	June 8, 1918	Pumpkins, 3 rows	Quite a few beetles	None
Kerosene emulsion 1-10	Sprayed	June 8, 1918	Pumpkins, 3 rows	Not many beetles	None
Air slaked lime	Dry on leaves	June 8, 1918	Melons, 1 row Cucumbers, 1 row	Thysanurids Only a few beetles	Burned slightly
Lead Arsenate	Dry on leaves	June 8, 1918	Cucumbers, 2 rows	Thysanurids Only a few beetles	None

The treatments giving favorable results, in the order of their effectiveness, are as follows:

Lead Arsenate and Powdered Sulphur equal parts, dusted on both sides of the leaves caused no injury and very few beetles were found feeding on the plants in the two rows treated.

Lead Arsenate was fairly effective.

Dry Bordeaux, where it did not wash off, seemed to prevent injury by the beetles. Doubtless acted as a repellent.

Land Plaster and Ground Limestone did not adhere to the leaves in a satisfactory manner, and for that reason was less effective than some of the finer and lighter powders.

Air-slaked Lime, though fairly effective in keeping off the beetles, caused some burning of the leaves.

Fish Oil and Sawdust mixed together and sprinkled on the ground around the plants seemed to repel the beetles until the plants were out of danger.

Any of the dry powders will adhere better and prove more effective, if applied to moistened foliage, in early morning when still wet with dew, just after a shower, or after first wetting the plants by spraying them with water.

SPRAYING EXPERIMENTS AT CLINTONVILLE.

By M. P. Zappe.

These experiments were conducted in the orchard of S. A. Smith & Son, near the Clintonville railroad station in the town of North Haven. It is the same orchard where work was done last year an account of which was published in the report of this station for 1917, page 259.

The first application was made May 6th and 7th, just before the blossoms opened. A hard southwest wind in the morning of May 6th, prevented us finishing the spraying of the trees, and about two-thirds of each tree was covered with the spray. In the afternoon the wind subsided and these trees were finished. The remaining trees were sprayed the following day. Spray materials were applied as follows:

Rows 1, 3 and 4.

Lead arsenate (powdered)	3 lbs.
Nicotine solution	1 pint
Commercial lime-sulphur	2 gal.
Water	100 gal.

Rows 5 and 6.

Lead arsenate (powdered)	3 lbs.
Nicotine solution	1 pint
Copper sulphate	8 lbs.
Lime	8 lbs.
Water	100 gal.

Row 2 was left untreated as a check.

The orchard was sprayed again on May 17 and 18, just after the petals had fallen. The bloom was very light, especially on the Baldwins. At this time insects were scarce in the orchard; few aphids could be seen and a few canker worms were feeding upon the leaves.

Spray materials were applied as follows:

Rows 1, 3, 4, 5, and 6.

Lead arsenate (powdered)	3 lbs.
Nicotine solution	1 pint
Commercial lime-sulphur	1½ gal.
Water	100 gal.

The fruit was harvested and scored on September 20, 21, 23 and on October 15. Though the bloom was light the yield of first class fruit from the orchard was larger than last year, due no doubt to the absence of aphids which were present last year and stunted some of the fruit rendering it worthless except for cider.

Altogether 14,961 apples were examined. The results are not striking and apparently red bugs were not abundant. The figures are given below:

ROW	I Per cent.	*II Per cent.	III Per cent.	IV Per cent.	V Per cent.	VI Per cent.
Good	83.1	75.1	90.1	83.3	76.6	83.7
Codling Moth	6.1	5.	7.9	7.2	6.5	9.9
Curculio	4.5	7.8	.6	6.5	14.4	4.1
Maggot	.3	.1	.0	.3	.01	.3
Other chewing insects	3.9	6.7	.5	1.7	1.2	.9
Red Bug	1.1	4.8	.3	.7	.9	.9
Aphid	.7	.1	.1	.3	.01	.0

* Check. No treatment.

TESTS OF SPRAYS TO CONTROL THE POTATO APHID.

By W. E. Britton and M. P. Zappe.

The usual methods of spraying to kill aphids on potatoes have been more or less unsatisfactory because nicotine solution in combination with lead arsenate, or Bordeaux mixture, or both, does not spread as freely and is not as effective as when used with soap in spite of the fact that statements are often made that these materials will take the place of soap. There is some danger in combining the soap-nicotine mixture with lead arsenate because many of the soaps contain a free alkali, usually sodium, in the form of hydroxide or caustic, and this unites with the arsenic in the poison forming sodium arsenate, a substance which is soluble and destructive to plant tissues. If used in Bordeaux mixture, the soap tends to form a sticky substance which clogs pump and nozzles.

The nicotine-soap spray may be applied separately and this is often recommended and practiced. But this means an additional operation at a time when each day counts and each man's services are valuable, if indeed, help of any kind be procured, which was difficult in 1918. Hence, to save labor it is desirable and important to reduce the number of spraying operations to the minimum, but this must not be done at the expense of effectiveness, and the risk of injury must not be too great.

In order to devise a rational treatment whereby some of these insecticides may be combined, a number of tests were made of promising materials during 1918. The different materials were prepared with the co-operation of Dr. E. M. Bailey of the chemical department of the Station and the field tests were made by Mr. Zappe on potatoes growing at the Station farm at Mount Carmel. These potatoes were infested with aphids which were increasing in abundance and it was evident that the pest must be checked soon or the crop would be greatly lessened. The tests were made from June 29 to July 26. The materials tested were as follows:

Nicotine Solution.

"Black Leaf 40," one teaspoonful in one gallon of water killed only a few aphids, apparently because the aphids are not wetted by the spray. The waxy or oily excretions, cause the spray to roll off in drops without really coming in contact with their bodies. When

the same proportion of nicotine was used and enough soap added to made the mixture feel soapy, and suds appear readily when shaken, it will kill a large percentage when sprayed upon them.

SALT SOLUTION.

Common salt, one ounce in one gallon of water, neither killed any aphids, nor caused injury to the foliage.

COMMERCIAL LIME-SULPHUR.

This liquid one part in 50 parts of water, killed only a few aphids and caused no injury to the plants.

COMMERCIAL LIME-SULPHUR AND NICOTINE SOLUTION.

Commercial lime-sulphur and nicotine solution ("Black Leaf 40") one tablespoonful in one gallon of water, killed a few aphids and caused no injury to the foliage.

NICOTINE SOLUTION AND MOLASSES.

Nicotine Solution ("Black Leaf 40") one teaspoonful, molasses, one tablespoonful, in one gallon of water killed a few aphids and caused no foliage injury.

CASEIN, ARSENATE OF LIME AND NICOTINE SOLUTION.

The use of casein as a spreader has been recommended by several workers, especially when used in connection with lime. Consequently this was thought worthy of trial and was employed in our tests. Professor Lovett* regards it as being worthy of much additional study. The material was prepared as follows:

Quick Lime	3.5 grams
Powdered Casein	1.5 grams

This was made into a thin paste by the addition of water, and continual stirring, and used at the rate of 4 ounces of this paste in a barrel of 50 gallons of spray mixture. "Black Leaf 40" was used at the rate of one teaspoonful in a gallon of water, and poison was added in the form of lead arsenate (powdered) one ounce. In another lot the same weight of calcium arsenate was used. The latter caused some injury to foliage, but no injury followed the use of lead arsenate. The casein in the amount used was of questionable value as a spreader and did not seem to render the nicotine solution any more effective in killing aphids.

* Journal of Economic Entomology, Vol. II, p. 66, 1918.

By this time the aphids were increasing rapidly and must be checked to save the crop. Many of the dealers had sold out on nicotine solution and others had raised the price. The following materials were used independently of arsenical poisons, in an attempt to control only the aphids.

Nicotine Oleate.

The possibility of this material was first brought to our attention by a note published by William Moore* and it was prepared as follows:

"Nicofume"	3.25 grams
Oleic Acid or Red Oil	2.28 grams
Water	1 gal.

This material did not spread as satisfactorily as "Black Leaf 40" and soap, and was not any more effective in killing aphids. It was easy to make and apply and caused no injury to the plants.

Nicotine Oleate and Soap Bark.

This was prepared after the following formula:

"Nicofume"	5 grams
Oleic Acid or Red Oil	3.5 "
Soap Bark	5 "
Water	1 gal.

The soap bark was made into an infusion and added to the combination. As an aphid-killing spray this was slightly more effective than the preceding.

Glycerine (40 cc.) was substituted for the soap bark, and when sprayed upon the plants killed many aphids but neither preparation seemed to be any more effective than "Black Leaf 40" and soap.

Kerosene Emulsion.

The directions for making kerosene emulsion usually call for one-half pound of soap, 2 gallons of kerosene, with a dilution sufficient to make about 30 gallons. These are the amounts named in the Station Spray Calendar (Bulletin 199) published a year ago. When tried against the potato aphid, there seemed to be too much kerosene for the soap and some "burn" or injury resulted. Consequently the proportion of soap was increased and a lesser dilution used. Soap was purchased by the box at wholesale price, and the cakes averaged about 10 ounces in weight.

* Ibid, page 341.

As it seemed desirable to make just enough each time for a barrel of mixture, the quantities may be stated as follows:

Kerosene	4 gal.
Soap (about 30 ounces)	3 cakes
Water to make	50 gal.

The soap was shaved into thin slices with a tool for shredding cabbages, and dissolved in hot water on a stove which had been taken into the field for the purpose as is shown on plate XXVIII, a. The hot soap suds and kerosene were churned by means of a bucket pump, until a creamy mass was formed in which the oil did not separate on standing. The operation is shown on plate XXVIII, b.

This emulsion was used independently of arsenical poisons and was very effective in killing aphids. All that were hit by it died at once. A slight injury to foliage was noticed, and the formula changed by increasing the soap and diminishing the kerosene as follows:

Kerosene	3 gal.
Soap (about 40 ounces)	4 cakes
Water to make	50 gal.

This formula scemd to be as effective in killing aphids as the preceding and there was no injury to foliage. A greater portion of the field was sprayed with kerosene emulsion a hand barrel pump being used as is shown on plate XIII, b, of Bulletin 208, which is a part of the Station Report for 1918.

The price of materials to make a barrel of spray liquid at this time were about as follows:

3 gallons kerosene @ .14 (retail)	$ .42
4 cakes soap @ .06 (wholesale)	.24
Total	$ .66

Nicotine solution and soap at current prices was more than twice as expensive, but required less work in preparation. The cost of nicotine and soap is given below:

Nicotine sulphate ("Black Leaf 40") 1 pint	$1.31*
Soap, three cakes, @ .06 (wholesale)	.18
Total	$1.49

Materials for the kerosene emulsion could be obtained of any grocer in city or country, and nicotine solution was hard to get on account of the unusual demand for it.

* In gallon lots.

THE ORIENTAL PEACH MOTH.

Laspeyresia molesta Busck.

Introduction.

In the report of this Station for 1917, page 315, an announcement was made of the occurrence of the Oriental peach moth in Connecticut, and such facts as were then known about this insect were included. Since the publication of last year's report additional information has been obtained, and it is deemed advisable to give here a summary of the status of this new and threatening pest of fruits.

Careful studies of the Oriental peach moth have been made by Dr. A. L. Quaintance and his associates, Division of Deciduous Fruit Insect Investigations, Bureau of Entomology, Washington, D. C., and by Dr. Philip Garman of the Department of Entomology, of the Maryland Agricultural Experiment Station, College Park, Md. The trial grounds of the U. S. Department of Agriculture, at Arlington, Va., where nearly all deciduous orchard fruits are injured have furnished a good opportunity for the work of Dr. Quaintance and his associates. College Park, Md., is not far away, so the results of the two separate investigations should correspond very closely. The Bureau of Entomology has published an illustrated poster showing the injury caused to the twigs and fruit and giving considerable information. A paper entitled "Further Notes on *Laspeyresia molesta*" by W. B. Wood and E. R. Selkregg of the Bureau of Entomology appeared in the Journal of Agricultural Research in April, 1918, Vol. XIII, page 59. Dr. Garman's preliminary studies were embodied in Bulletin 209 of the Maryland Agricultural Experiment Station, entitled, "The Oriental Peach Pest." From these publications most of the facts set forth in this paper, were gleaned.

A conference of entomologists, which the writer attended, was held at Washington, March 18, to consider this insect and control measures were discussed. It was agreed that the first essential was to scout around the infested points and in other places in each state to determine the present distribution of the pest. Consequently the Bureau of Entomology employed men to scout in the infested and other states; men for this work to be nominated by, and to be partly under the direction of, the entomologists in the states where they are at work. Mr. Ernest D. Brown of Clinton, Conn. was appointed to scout Connecticut and began April 1. Mr.

Zappe worked with him in Stamford and Greenwich for the first ten days to get the work properly started. Mr. Brown worked in the State until about October 1st, when he examined portions of Rhode Island, Massachusetts and New Hampshire. He covered the shore region in Connecticut and made many trips inland, especially to visit large orchard areas. He also accompanied the men while inspecting nurseries, and in this way examined many nearby fruit trees as well as trees in the nurseries.

Original Home.

It is believed that this insect was introduced into the United States a few years ago on flowering cherry trees from Japan. On rearing the adult from the larva, it proved to be new to science. Since then, the same species has been reared from nursery stock coming from Japan.

Distribution in Connecticut.

Our knowledge of the distribution of this insect in Connecticut is based upon the inspections of Mr. Brown in 1918. Strange to say the only specimens of this insect found were larvae in Stamford, near where it was first discovered in 1917. Here the larvae were found boring in the twigs and later tunnelling in the fruit.

Twig injury was found in each of the four Southern or shore counties but was not discovered in the orchards far inland, or in the northern counties. This twig injury may have been caused by the Oriental peach moth, or by the peach twig borer *Anarsia lineatella* Zell. which does similar injury. The former has a pinkish white larva and the latter a brown larva, so when the larva is found in the burrow, there is no uncertainty but when only empty burrows are found it is not possible in most cases to determine which insect excavated them.

Therefore the reported "typical injury" may not mean that the Oriental peach moth is present. Such injury was found by Mr. Brown in each of the following towns, arranged by Counties:

Fairfield County: Greenwich, Westport, Fairfield, Darien, Stratford, Norwalk, New Canaan.

New Haven County: Milford, Woodbridge, New Haven, North Haven, Branford, Cheshire, Guilford, Wallingford, Madison.

Middlesex County: Clinton, Old Saybrook.

New London County: Old Lyme, New London, Niantic.

The insect itself was found in the town of Stamford.

Distribution in the United States.

The Oriental peach moth is now known to occur in the District of Columbia, Northern Virginia, Maryland, Southeastern Pennsylvania, Northern New Jersey, Southeastern New York, Connecticut and probably Northern Delaware. So-called typical injury was found in Delaware, Mississippi, and West Virginia and doubtful injury in two or three other states but as has already been stated both the typical and doubtful injury may have been caused by *Anarsia*. Further searching may reveal the presence of *Laspeyresia* in other sections, but so far the evidence is negative as many other states have been scouted without finding any traces of the insect, or of any suspicious twig injury.

Status as a Pest.

It is yet too soon to determine whether or not this insect will become an important pest in the commercial orchards of the Eastern States. In the vicinity of Washington, D. C., it appears to be very destructive. In New Jersey thus far the injury to fruit has been negligible in commercial orchards and there are about three injured twigs per tree. In the orchard of the Maryland Agricultural College, according to Professor E. N. Cory the average injury is less than three per cent. and the maximum injury is about 12 per cent.

In Connecticut the twig injury has been scattered and not abundant in commercial orchards, and the only larvae found were in city back yards in the vicinity of Stamford.

It is never wise to make predictions. Entomologists who have observed the work of this insect near Washington, D. C., regard it as a serious and threatening pest. The observations made in New Jersey and Maryland lead us to hope that it may not prove so destructive as was feared.

Injury to Twigs.

The larvae of the Oriental peach moth seem to show a preference for peach and quince twigs, over the twigs of other kinds of fruit trees, and if the insect is present in a locality where peaches are grown, some injured twigs can usually be found. This injury is always to the newest growth and often causes the twigs to branch and thicken at their terminals. Such twigs are easily seen on the dormant trees in winter.

The larvae which live through the winter usually attack the new shoots in May, often causing the terminal leaves to turn brown and die. Such a condition may be found on peach, quince and on sweet cherry, but seldom occurs on other kinds of trees. The larvae may forsake their burrows and enter other twigs, thus injuring several twigs or perhaps trees. Injured twigs are shown on plate XXIX, b.

Injury to Fruit.

Though called the Oriental peach moth, it is by no means confined to the peach, and this is even more evident concerning fruit injury than twig injury. The first injury is noticed in peaches when the fruit is about the size of chestnuts. In other kinds of fruits the injury shows somewhate later. The first-brood larvae tunnel in the twigs early in the season.

The second-brood larvae also work in the twigs but when about half grown some of them attack the fruit, boring into the side of a green peach and living therein until mature. They sometimes emerge at the entrance hole but usually elsewhere. The green fruit usually exudes drops of gum, but does not fall from the tree or decay.

The third-brood larvae generally hatch when the early varieties are ripening. Some tunnel first in the twigs, and later in the fruit. Others go at once into the ripening fruit usually near the stem, and work beneath the skin of the softening fruit and inward to the seeds and along the grooves in the pit. Entrance to a fruit is also gained where covered by a leaf or where two fruits touch each other. When the Elberta and later varieties are ripening, the fourth-brood larvae hatch and go at once into the fruit. This is when the greatest damage is done, and the injury may continue until all peaches have been harvested. Garman* found that from 5 to 15 per cent. of the fruit was infested in Maryland. The latter part of the summer and especially in September the larvae attack apples and quinces often causing serious injury. Wood and Selkregg** record the rearing of 354 larvae from one and one-half bushels of Ben Davis Apples and more than half of the apples in the orchard were injured. In quince an average of nine larvae per fruit occurred, and in one quince 30 larvae matured.

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* Bulletin 209, Maryland Agricultural Experiment Station, 1917.

** Journal of Agricultural Research, vol. XIII, page 63, 1918.

Thus it will be seen that this insect threatens the fruit-growing industry wherever it occurs. An infested peach is shown on plate XXIX, a.

Number of Broods.

Garman* states that there are four generations each year, but Wood and Selkregg** mention the larvae of the fifth generation as hatching late in the season and attacking peach twigs.

Food Plants.

This pest has been reported as injuring the twigs of peach, plum, cherry, flowering cherry, quince, apricot, and apple very slightly. The larvae infest the fruit of peach, quince, pear, apple and flowering quince.

Life History and Habits.

The eggs are laid singly on the under side of the leaves on peach. Near Washington, D. C., the first eggs were deposited May 2, and the last ones October 8. The period of incubation varies from four days in midsummer to seven days in cooler weather. The larval period varies from 8 to 13 days with an average of about 11 days, during which time the larvae are feeding in twigs or fruit. Larvae often leave their feeding places and enter other twigs or fruit, and though there is usually only one larva in a twig, many may infest a peach or quince at the same time.

According to Dr. Garman* larvae obtained from eggs deposited after August 25, hibernated in cocoons after the first of September, but did not pupate. This is probably the usual method of hibernating. The pupa stage lasts from 9 to 13 days with an average of 10 days, during the growing season. When mature the larva eats out cavities in the sides of the twigs, or whatever surface is near at hand and suitable for the purpose, and there constructs a firm cocoon, those found late in the season usually being in crevices in the bark and very inconspicuous and difficult to detect.

The entire life cycle lasts about 26 days. The adults fly and lay their eggs during the night.

Means of Spread.

There is some danger that this insect may be disseminated by means of nursery stock as the winter cases or cocoons are sometimes

* Bulletin 209. Maryland Agricultural Experiment Station, 1817.
** Journal of Agricultural Research, Vol. XIII, page 63, 1918.

made on nursery trees. Probably the pest was brought into this country on nursery stock. So far, though much searching has been done, this insect has not been found in Connecticut nurseries. The principal means of spread, other than that of natural flight, seems to be by the way of fruit. The danger of dissemination in fruit as compared with nursery stock is in the ratio of about 95 to 5, in the opinion of those who have studied the pest. Any infested fruit taken into a new region, if not destroyed at once, may start a new colony. If the fruit is stored for a time or if discarded cores and parings are thrown out, the larvae will emerge and may attack nearby trees, or if mature, will transform. Females emerge from the cocoons and lay eggs. In this manner the pest may soon become widely distributed.

Natural Enemies.

In Maryland according to Dr. Garman,* two parasites have been reared, both belonging to the hymenoptera or four-winged flies. One, a chalcid, *Trichogramma minutum* Riley was reared from the eggs, 80 per cent. of which were parasitized. The other a braconid, *Macrocentrus* sp. was reared in small numbers from the larvae.

Wood and Selkregg** have reared six primary hymenopterous parasites, of which *Macrocentrus* sp. was the most abundant. This species is also a parasite of the codling moth *Phaeogenes* sp. was second in point of abundance, and several specimens of *Ascogaster carpocapsae* Viereck were obtained. There were also reared one specimen each of *Glypta vulgaris* Cress., *Spilocryptus* sp. and *Mesostenus* sp. Two secondary parasites were obtained, *Dibrachys boucheanus* Ratz., and *Cerambycobius* sp.

One dipterous parasite *Hypostena variabilis* Coq. belonging to the family Tachinidae was obtained from a cocoon.

It was reported by Professor E. N. Cory, State Entomologist of Maryland that about 60 per cent. of the larvae and 50 per cent. of the pupae were parasitized in Maryland.

There is evidence to show that the larvae are eaten by spiders and by lace-wing larvae, and that the cocoons in some instances are opened by woodpeckers, and the contents devoured.

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* Bulletin 209 Maryland Agricultural Experiment Station, 1917.

** Journal of Agricultural Research, Vol. XIII, page 70, 1918.

DESCRIPTION.

EGG. Diameter about .7 mm., white, circular, flat, with surface sculptured; the center granulate with reticulate ridges extending a short way inward from the margins. Somewhat smaller and less reticulated than the egg of the codling moth.

LARVA. Length about 12 mm., white varying to pink with head black and shining. Prothoracic and anal shields yellow to brown. Spiracles small, circular, dark brown or black. Brown lateral and dorsal setae are borne on each segment.

PUPA. Length 4.5 to 5.5 mm. uniform brown, smooth: abdomen composed of ten segments, the last three apparently grown together to form a truncated cone. The basal margins of segments 2 to 7 each bearing dorsally a transverse row of heavy setae or spines.

ADULT. Wing expanse 10 to 15 mm. (about half an inch) fore-wings, predominant color dusky brown, rather indistinctly marked with a row of short diagonal double dashes on the costal margin, with intervening spaces blackish and produced into indistinct wavy lines extending partly across the wings. Towards the distal margin and parallel with it is a curved row of six small dark spots surrounded by whitish scales; often with a curved dark band inside this row of spots. Rear wings dark brown with the front margins white, and the female with a yellowish area along the rear angles.

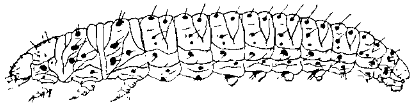

Figure 8. Larva of Oriental peach moth, about four times enlarged. (After Wood and Selkregg, Bureau of Entomology, U. S. Dept. of Agriculture.)

The larva is shown in figure 8, and the adult in figure 9.

For a more detailed description, see Report of this Station for 1917, page 317, where Busck's original description is reproduced.

CONTROL MEASURES.

The ordinary sprays are not very effective in controlling the Oriental peach moth, though may somewhat reduce the percentage of injury. Garman reports the most success with a spray of self-boiled lime-sulphur, to which calcium arsenate and tobacco had been added, following a winter spray of lime-sulphur. Nicotine solution and soap did not decrease the infestations over the check or untreated trees.

The Federal Entomologists experimented with various spray mixtures but found none that gave positive results in controlling the pest. Likewise fumigation with hydrocyanic acid gas failed to kill

larvae in gummy peach twigs or in their winter cocoons on nursery stock. Clipping off and destroying the twigs gave only a partial measure of control and was too laborious to be practicable. Dipping in miscible oils, even as concentrated as one part in ten parts of water, did not kill the larva.

Thus it appears that the Oriental peach moth is a most difficult pest to control and it is to be hoped that the parasites may soon reduce its numbers to the minimum.

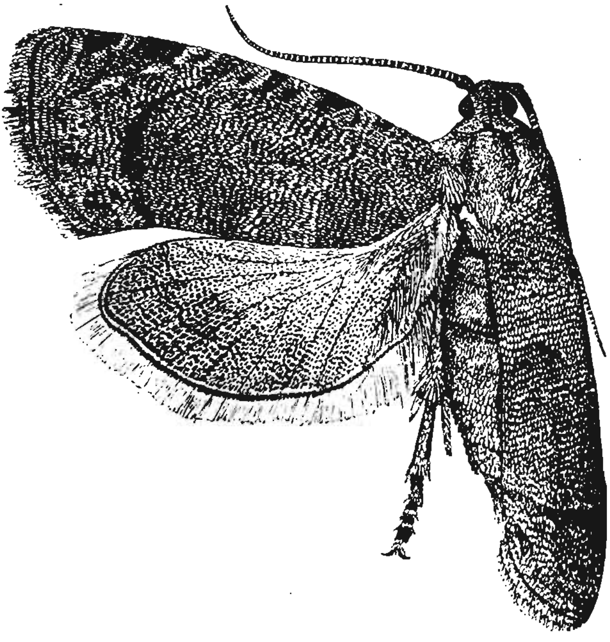

Figure 9. Oriental peach moth, enlarged about ten times. (After Wood and Selkregg, Bureau of Entomology, U. S. Dept. of Agriculture.)

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THE PEACH TWIG BORER.

Anarsia lineatella Zell.

In the work of Mr. E. D. Brown in searching for the Oriental peach moth *Laspeyresia molesta* Busck. in Connecticut, our attention was called to the presence of the peach twig borer in an extent not before realized. Reference has already been made to this insect on page 299, and how the larva may be distinguished from that of the Oriental peach moth, but a more comprehensive account is given here for the information of the fruit growers of the state, who more than ever before will notice the borers in the twigs of their trees. This insect occurs in Europe and since 1860 has become distributed throughout the United States and Canada where peaches are grown. Though it is occasionally troublesome in the Eastern states it is on the Pacific coast where it does the most damage, causing a loss of twenty-five per cent. of the crop in certain regions.

In searching for the Oriental peach moth, the field agents of the Bureau of Entomology found the peach twig borer present in Connecticut, New York, New Jersey, Delaware, Pennsylvania, Maryland, Virginia, West Virginia, North Carolina, Ohio, Oklahoma, but strange to say did not obtain it in California or elsewhere on the Pacific coast where it is reported as doing the most damage.

The life-history of the peach twig borer is very similar to that of the Oriental peach moth: it hibernates in the larval stage: there are four broods each season: the over-wintering larvae tunnel in the new growth: the larvae of later broods infest the fruit: its attacks are not confined to peach alone but plum, apple and pear are sometimes injured. It is the stone fruits, however, that are usually attacked.

The peach twig borer has a brown larva which may be readily distinguished from the pinkish-white larva of the Oriental peach moth.

Distribution in Connecticut.

Our records show that during 1918, the peach twig borer was taken by Mr. Brown in Stamford, Norwalk, Wallingford and Old Lyme. There were many cases of twig injury in the towns of Greenwich, Stamford, Darien, New Canaan, Norwalk, Westport, Fairfield, Stratford, Milford, Orange, New Haven, Branford, Guilford, Madison, Seymour, Woodbridge, Cheshire, North Haven, Meriden, Wallingford, Clinton, Westbrook, Old Saybrook, Essex, Saybrook, Chester, Old Lyme, Lyme, East Lyme, and New London which may have been caused either by the peach twig borer or by the Oriental peach moth, as it is impossible to distinguish the work of one from the other when specimens of the insect are not present. The data obtained indicate that both insects are more common along the coast than inland as no twig injury was observed at the points visited in Danbury, Bethel, Wilton, Trumbull, Hartford, East Hartford, Manchester, Southington, Middlefield, Middletown, Haddam, Groton, Ledyard and East Hampton.

Injury to Twigs and Fruit.

The over-wintering larvae tunnel into the new shoots in spring causing them to die. A tree badly infested looks as though it had been scorched by fire. The larvae of later broods also burrow in the twigs of the new growth, but soon attack the fruit, especially of late varieties late in the season. Smith* states that in New Jersey, "the larva has been recorded in woody excresences of plum, peach and apple and in stems of strawberry. I have seen it only boring in the tips of peach twigs; but not in destructive numbers." The larvae after burrowing in the shoots leave their twigs and attack others, thus causing considerable injury and Slingerland and Crosby** claim that "three or four larvae have been known to kill a three-year-old peach tree by destroying all the new growth."

According to Marlatt† the peach twig borer is considered one of the three or four worst insect pests of California, and that it is very destructive to peach, plum, apricot, and almond in western Colorado. In addition to the fruits mentioned it also attacks nectarine, prune and pear on the Pacific slope.

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* Insects of New Jersey, page 560, 1909.

** Manual of Fruit Insects, page 285, 1914.

† Farmer's Bulletin, No. 80, page 3, U. S. Dept. of Agriculture, 1898.

DESCRIPTION.

EGG. About 4 mm. long, 2 mm. thick, ovoid, white, turning to orange, fastened lightly lengthwise to the twig. Under the microscope the surface appears reticulated.

LARVA. 10 to 12 mm. (half an inch) long, rather stout, tapering strongly toward either extremity, dull reddish-brown; head and cervical shield dark brown or black. Lighter spaces or rings are noticeable between the segments. Ventral surface lighter. Hairs rather long and borne singly from small tubercles.

PUPA. 6 to 7 mm. long, rather robust, brown, fastened by a few threads to bark, shriveled leaves or rubbish.

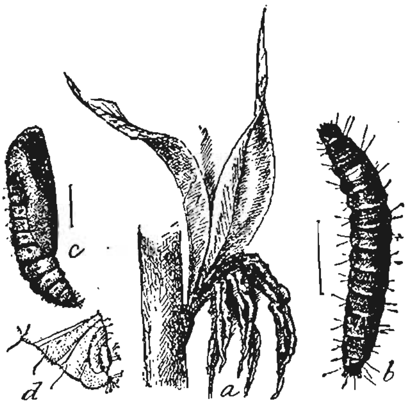

Figure 11. Peach twig borer: *a*, new growth withering from attack of larva; *b*, larva, about three times enlarged; *c*, pupa, about four times enlarged; *d*, tip of pupa, side view, much enlarged. (After Marlatt, Bureau of Entomology, U. S. Dept. of Agriculture.)

ADULT: Wing-expanse about 12 mm. (half an inch) steel gray with darker spots on forewings. Wings narrow and the rear margin of the hind wings and tips of forewings are heavily fringed with gray.

The adult is shown on plate XXX, a, and the larva in figure 11.

METHODS OF CONTROL.

In California and other places where extensive tests have been made, experience shows that the peach twig borer may be controlled by spraying with lime-sulphur or miscible oils in late spring just after the buds begin to swell. The treatment may be kept up until the first blossoms appear.

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LIFE HISTORY AND DEVELOPMENT OF THE GREENHOUSE COCKROACH.

Pycnoscelus surinamensis Linn.

By M. P. Zappe.

In the Report of this Station for 1917, pages 302-315, was published an account of this insect, its distribution, synonymy, injury, description of adult and egg, egg-laying habits, literature and the control methods tested in a Connecticut greenhouse.

As there appeared to be no descriptions of immature stages, and nothing in literature concerning the life history of this species, an attempt was made to follow its development under laboratory conditions, from the egg to the adult stage. The following notes, therefore, are the results of these observations:

Effect of Temperature.

It was noticed in the greenhouses where this roach was doing damage that the greatest numbers were found in the houses immediately adjoining the heating plant. They were also numerous in a house just above the boilers. In the rose houses where they were more plentiful than anywhere else the temperature was always kept between 70° and 80° F. during the day and at night was never allowed to get below 60° F.

In November 1917, a large number of living roaches were collected and were taken back to the laboratory for study. At that time there was no heat in the laboratory for a few weeks and some of the coldest days the temperature went down to between 36° and 40° F. This cold lasted for nearly a week and about 95 per cent.

of the roaches died and the others seemed to be dead but when removed to another room where the temperature was about 65° F. a few of them showed signs of life, finally revived and lived for some time afterward.

Five adult roaches were exposed to a temperature of 30° F. for an hour and appeared to be dead but when returned to normal room temperature they all came back to life in about 20 minutes. Another lot was exposed for 2 hours to a slowly rising temperature from 30° to 36° F. They all survived this treatment but when exposed overnight for about 15 hours at a temperature of 24° F. they all died.

Another lot of roaches was exposed to a temperature of 1° F. for only 10 minutes which proved fatal to them all.

This species of roach like some of the other species, likes moisture; in fact it must have a certain amount of moisture in order to live. In the laboratory roaches which were kept in test tubes, dry sand and dry boxes usually died in a few days. It became necessary to keep a moistened blotter in each cage or else add a little water to the sand in the cage where they were confined.

Natural Enemies.

With the exception of a mite which caused the death of quite a number of the roaches in our study cages no parasites of this species have been seen in Connecticut.

Life History.

There are six moults from egg to winged or adult stage. The time required to cover this period varies quite a little with different individuals. Out of a brood of young from the same mother, in the same cage, with all conditions of temperature, moisture, food, etc., the same, the time varies six or seven weeks. The average length of time to reach the adult stage is about seven and one-half months. It takes from fifty to one hundred days from the time it reaches the winged or adult stage for an adult roach to produce a brood of young. This makes the total time from one generation to another approximately ten months.

Moults.

First instar. **Very young nymphs only a few hours old. Length about 3 mm., width 1 mm. Color whitish, eyes, mandibles and tarsal joints brown, rest of nymph turns light brown after several hours.**

SECOND INSTAR. Length 5 mm., width 2 mm. Color light brown, head and thorax darker than the abdominal segments. Body above shiny. There are eight abdominal segments, the distal five of which are not so shiny as, and a little darker than, the other three segments. Antennae same color as body, except basal and two distal joints which are lighter colored. Under side of body including legs, tarsi, labrum and palpi much lighter than the rest of body.

THIRD INSTAR. Length 6 mm., width 3.5 mm. Color much darker, almost black, shiny, last five abdominal segments not so shiny. Last thoracic segment covers ends of first abdominal segment and about one-half of the second segment. Under side of body much lighter than rest of body. Tibiae and tarsi lighter than underside of body.

FOURTH INSTAR. Length 10 mm., width 6 mm. across abdomen which is the widest part of body. Color a little darker than in previous moult. Abdomen much broader in comparison with head and thorax than in last moult.

FIFTH INSTAR. Length 18 mm., width 9 mm. Color same as in last intar. Last five segments of antennae lighter than others.

SIXTH INSTAR. Length 20 mm., width 8 mm. Color same as in last two instars. Roach not so flattened, more convex than in other moults. Much longer and not so wide as in previous instars.

SEVENTH INSTAR. Adult winged stage. (For description see Report of this Station for 1917, page 306.)

OCCURRENCE OF THE EUROPEAN HOUSE CRICKET IN CONNECTICUT.

Gryllus domesticus Linn.

By M. P. ZAPPE.

This insect often called "the cricket on the hearth" was reported from Shelton, in July, 1918, where it was living in the attic of a new house and annoying the occupants by its nightly chirping and by getting into the food in the pantry on the floor below.

The complaint was investigated, July 29th, by the writer. There were great numbers of crickets in the attic, with considerable old clothing stored there, some of which had been eaten into by the crickets. During the day they were in hiding and comfortably quiet, but at night they chirped incessantly making considerable noise. There were two rooms in the attic, one of which was used as a sleeping room. The other was used as a sort of store room. At the time of the writer's first visit, there was a crookneck squash in

this storage room which had its entire inside, seeds, pulp and all eaten out by the crickets. A great number of them were hiding between the rafters, roof boards and shingles. They were gnawing into the wood and the floor was covered with bits of chewed wood.

At night they came downstairs and got into the pantry where they ate into all sorts of food that they could get at. They seemed to be particularly fond of bananas. A few could be found in the daytime in the drawers in the pantry, in the flour, etc., and were as much of a pest as cockroaches. The amount of food actually eaten was not so great as that soiled by them and thus rendered unfit for use.

It is hard to understand just where these crickets came from, unless they had been present in the office of a large garage next door, and from there had entered this residence. None of the other houses in the immediate neighborhood had been troubled with this pest.

DISTRIBUTION.

This species is common in most all of the European countries and it is also present in Asia, Africa and Australia. In Spain it is a source of pleasure often being kept in cages much like we keep canary birds. Its first introduction into America was probably at an early date, at least in portions of the country. Kalm, writing of this insect in 1749 says "it is abundant in Canada especially in the country where these disagreeable guests lodge in the chimneys; nor are they uncommon in the towns. They stay here both summer and winter and frequently cut clothes to pieces for pastime."* The year before, however, he writes that he had not met with them in the houses in Pennsylvania or New Jersey.

In the United States it occurs sparingly in practically every state east of the Rocky Mountains.

HABITS.

The house cricket usually occurs on the ground floor of dwellings and evinces its liking for warmth by often occurring in the vicinity of fireplaces, concealing itself between the bricks of the chimney or behind baseboards, frequently burrowing into the mortar of walls. It is rarely abundant but at times multiplies excessively and be-

* Travels Vol. I, page 318: II page 256.

comes a very serious menace. During the winter it remains torpid but under the influence of warmth becomes active and musical.

It is mainly nocturnal in its habits coming out at dusk and roaming around the house for whatever food materials it may discover. It will often cut and injure fabrics and is particularly apt to cut into wet clothing evidently on account of its liking for moisture. The common field crickets are apt to get into houses and try their jaws on all sorts of clothing particularly woolens. Dr. Lintner* records the case of a suit of clothes just received from the tailor which was completely ruined in a night by common field crickets.

There is a popular superstition also to the effect that if a cricket be killed its relatives will promptly cut the garments of the offender.

In Europe and undoubtedly also in this country the hearth cricket is found in houses in all sizes from the very young to the full-grown insects, and probably often deposits its eggs and goes through its entire transformations within houses. During the summer it also appears frequently out of doors in Europe about hedges and in gardens returning to the house for protection on the approach of cold weather and being apparently unable to winter out of doors at least in cold climates. In this country it has been taken out of doors at electric lights. Its eggs judging from our knowledge of allied species are deposited in clusters and the young resemble their parents closely except in size and in lacking wings; they present also no variation in habit.

Description.

The adult is pale yellowish brown or straw-color with reddish brown markings on head and pronotum. Tegmina reaching nearly or quite to the tip of the abdomen, sometimes with reddish brown spots on their basal third. Inner wings either abbreviated or extending considerably beyond the ends of tegmina. Hind femora short and slender. Ovipositor about one and one-fifth times the length of the hind femora, pale brown becoming darker towards the tip. Both sexes are shown on plate XXXIII, c.

Control Measures.

On July 29, two kinds of poisoned bait were tried as follows: (1) Potato flour which had been soiled by the crickets, ½ pound; Borax, ½ pound; one mashed ripe banana. This was all mixed together and enough water added to make a thin paste.

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* 8th Report Ins. N. Y., page 179.

(2) Bicloride of mercury, one tablet dissolved in ½ cupful of water; this was added to a cupful of flour. The skin of a banana was cut up into small pieces and put into the bait.

Two days later, on July 31st, the house was visited again and all the poisoned bait had been eaten. A great many of the crickets had been killed, but there were still a few alive. As all the bait was eaten it was hard to tell which of the two baits was the most effective. The treatment was continued until August 9th. Then the lady of the house reported all the crickets gone, that she had neither seen nor heard any for a few days and it was safe to assume that they were all dead.

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THE EUROPEAN CORN BORER. A DANGEROUS INSECT WHICH MAY OCCUR IN CONNECTICUT.*

Pyrausta nubilalis Hbn.

On September 6, the writer attended a conference of entomologists at Boston to discuss methods of controlling the European corn borer *Pyrausta nubilalis* Hbn., an insect formerly known in Europe as *Botys silacealis*, which was discovered in 1917 infesting corn in the vicinity of Boston. Each of the New England States and New York were represented, and several representatives of the Bureau of Entomology were present including the Chief, Dr. L. O. Howard. Though the conference had been called for 10 o'clock, A. M., the meeting was postponed until after luncheon, in order to first make a field trip to see some of the damage caused by this insect. Con-

* Since this was put in type, borers have been found in corn stalks, in Milford, which may prove to be this pest.

sequently we were taken in automobiles to a field of sweet corn in the town of Winchester, where the plants were seriously infested. Here on a truck farm a small field of corn surrounded by celery and other vegetable crops, afforded an excellent object lesson of what enormous injury might result in case this pest should spread to the large corn growing sections of the country.

The tassels were nearly all broken over and this is said to be the first noticeable sign of infestation. In the axil of nearly every leaf there was a heap of "sawdust" or "borings" as large as the end of one's finger. Larvae of various sizes were present tunnelling in the stalks and ears, some being nearly full grown and others not more than half-grown. Some were feeding at the tip of the ear like the corn ear worm *Heliothis obsoleta* Fabr., and others were boring in the stem of the ear or perhaps in the cob. There must have been several larvae somewhere at work in each stalk and many larvae in some stalks. It seemed as if every stalk was infested.

Mr. Donald J. Caffrey of the Bureau of Entomology who had been working on this insect for a greater part of the summer, and Mr. Stuart C. Vinal of the Massachusetts Agricultural Experiment Station who has been at work on the life history and habits of this insect for the last two seasons were both present and explained the habits of the larvae, and the injury caused by them. It seems that the small larvae begin work in the stem of the tassels when the latter are just beginning to show above the leaves. Many of the mature tassels were broken and had fallen over, the break sometimes occurring mid-way, and again near the tip or at the base. This falling over of the tassel or a portion of it is noticeable a short distance from the field and according to Mr. Caffrey is often the first indication that the crop is infested. Some of the small larvae may also bore into the mid-ribs of the leaves. As the larvae increase in size they abandon the smaller stems and tunnel in the larger stalks. Sometimes there are several larvae in the same stalk and sometimes one larva may leave its burrow and attack consecutively several different plants.

Not only was the corn attacked, but the pest is not confined to corn, as many of the weeds in the cornfield and particularly around its margins, were infested. We, therefore, saw barn yard grass *Echinochloa crus-galli* Linn., lamb's quarters, *Chenopodium album* Linn., red root pigweed *Amarantus retroflexus* Linn., with heaps of sawdust thrown out of the burrows and the larvae inside. This sit-

uation of course greatly complicates the question of eradication or control.

So far as known this insect works in all portions of the plant except the small fibrous roots. It occasionally tunnels downward in the main stem below ground, and Mr. Caffrey believes that it may attack any part of the corn plant above the surface of the ground.

At the conference at the State House in the afternoon, various phases of the problem were discussed, and from this conference and in conversation with the entomologists at work on the problem and from Bulletin 178 of the Massachusetts Agricultural Experiment Station, by Stuart C. Vinal, the following facts have been obtained, and are given here in order to call attention to this very destructive insect, which *may at any time* be found in Connecticut.

The European corn borer was reported as having been observed in Connecticut near Putnam in the fall of 1917, but on investigating the matter no traces of it could be found, and it is probable that the insect noticed was the stalk borer *Papaipema nitela* Guen. or the corn ear worm *Heliothis obsoleta* Fabr., both of which are common and occur all over the state.

Injury.

According to Mr. Vinal* the young larvae at first feed upon the unopened staminate flowers but soon leave these buds and tunnel in the tassel stem as has been mentioned, thus causing the tassel to break and fall over. No doubt this would have the effect of destroying or greatly reducing the pollen and thus affect the crop. Larvae also enter the sheath surrounding an internode, and feed on the inside of the sheath, later boring into the pith of the stalk where it excavates quite a large cavity. Such injury is usually confined to that particular internode; though sometimes the larva bores through a node, it usually turns backwards and tunnels in the same internode but in the opposite direction. Where several larvae are at work in a stalk, it soon becomes tunnelled to such an extent that it breaks over in the wind. Some of these boring larvae find their way into the pedicel or small stalk bearing the ear, causing it to droop and die before maturity; frequently one of these borers goes on into the ear or cob.

*Bull. 178, Mass. Agr. Expt. Statioı

Probably the most serious damage to the crop results from the attacks of the larvae of the second brood, a large percentage of which go into the ear immediately after hatching. Here they injure the ear much like the corn ear worm, and in addition to feeding upon the kernels they tunnel into or through the cob. In Massachusetts in 1918, 311 larvae were collected from one hill of corn. In Hungary in 1898, this insect is said to have destroyed one-fourth or 25 per cent. of the entire crop of field corn but the injury is estimated to be 90 or even 100 per cent. of the total crop in some parts of Russia. The first brood attack early sweet corn, but later in the season both broods attack the later corn and here the most serious injury occurs. Late in the season in Massachusetts the larvae went

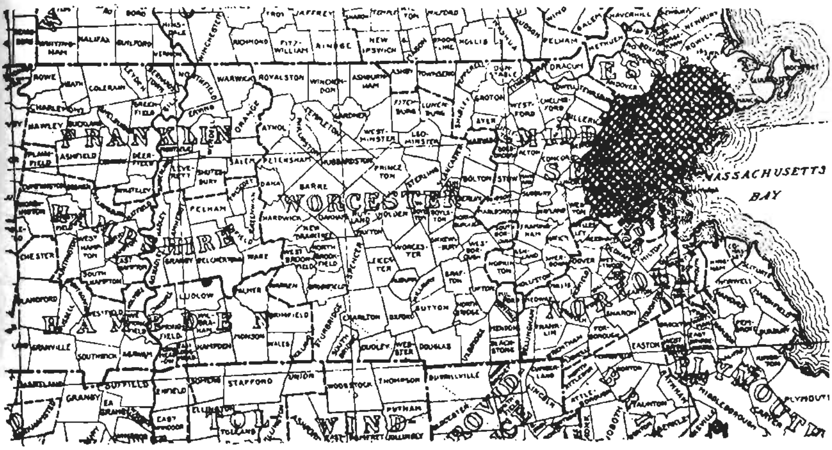

Figure 12. Map of Eastern Massachusetts, showing area (shaded) now occupied by the European corn borer.

from the corn into nearby celery, causing great damage as in some cases there were eight larvae in a stalk or 46 per plant.

Distribution.

The European corn borer is known to occur in Central and Northern Asia and Japan, the Southern and Central portions of Europe and in Egypt. In the United States, this insect is not known to be present except in one locality, in the eastern part of Massachusetts. The area infested includes 34 towns, extends only slightly south of Boston, a few miles westward, and perhaps twenty miles toward the north, approximating about 320 square miles including cities and waterways, and is shown in *figure* 12.

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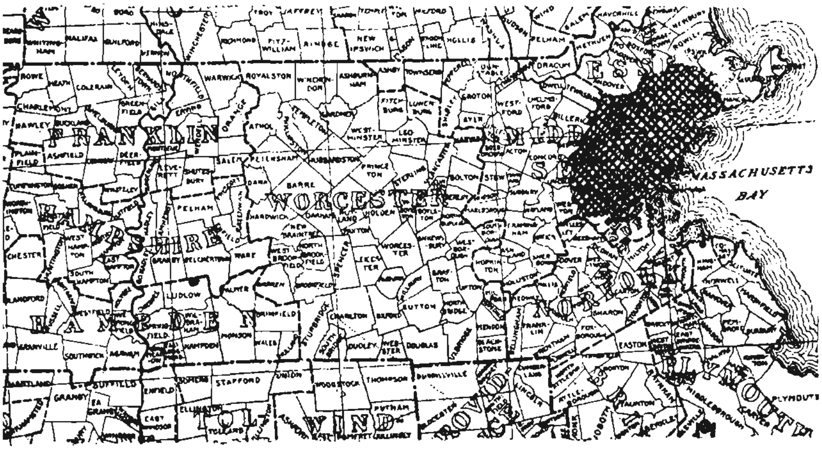

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Though discovered in Massachusetts in 1917 by Mr. S. C. Vinal, sweet corn grown in gardens ten to twelve miles inland had been attacked for the past three or four years. Mr. Vinal* concludes that the pest must have been brought to this country about 1910, probably in hemp imported by one of the cordage firms in the vicinity of Boston.

Food Plants.

Though corn or maize is the chief commercial crop attacked and injured in this country, the insect attacks a number of other plants including garden vegetables and the larger common weeds. Sweet corn is the crop most seriously injured. As a rule the moths will not lay eggs on the other plants if corn is available. The newly-hatched larvae may easily be blown upon any adjacent plants and will feed in some of them. In Europe besides maize, hops, hemp, cotton and millet are injured.

In Massachusetts according to Mr. Vinal the following plants have been attacked by *Pyrausta nubilalis:*

Corn *Zea mays* Linn. Celery *Apium graveolens* Linn. Barnyard grass *Echinochloa crus-galli* (L.) Beauv. Fox-tail grass *Setaria glauca* Beauv. Millet *Setaria italica* Kunth. Dock *Rumex* sp. Burdock *Arctium Lappa* Linn. Lamb's quarters *Chenopodium album* Linn. Red root pigweed *Amarantus retroflexus* Linn. Beet and Swiss Chard *Beta vulgaris* Linn. Tomato *Lycopersicum esculentum* Mill. Potato *Solanum tuberosum* Linn. Spinach *Spinacia oleracea* Mill. Ragweed *Ambrosia artemisiaefolia* Linn. Ladies' thumb *Polygomum persicaria* Linn. Dahlia *Dahlia variabilis* Desf. Chrysanthemum. Gladiolus *Gladiolus sp.* Bean *Phaseolus* sp. Bur Marigold *Bidens frondosa* Linn.

Habits and Life History.

No definite report on life history studies in this country are at hand, though Mr. S. C. Vinal was at work on the matter at the time of his death in September, 1918, and the results of his studies will probably be published in due time.

Apparantly the nearly mature larva passes the winter in the corn stalks, and pupation occurs within the burrow in the spring. The adults emerge probably the latter part of May. The females begin laying eggs on the corn stalks a short time after, and these eggs hatch in a few days. The young larvae feed upon the leaves and soon eat their way through the sheath, and tunnel in the main stalk. They

* Bull. 178, Mass. Agr. Expt. Station.

reach maturity the latter part of July and each excavates an opening to the burrow for the adult to escape, spins a silken partition above and below and pupates. In about two weeks the moths emerge and lay eggs for the second brood of larvae, which as a rule do not transform but hibernate as nearly mature larvae. There were indications of at least a partial third brood in Massachusetts in 1918.

The larvae will leave one plant and attack another.

Though the larvae usually pupate in their burrows, they will sometimes make this transformation in packing boxes, especially in the spring.

The adults are not especially attracted to lights.

Pyrausta nubilalis is not strongly parasitized either in Europe or in Massachusetts though Kostinsky* mentions that both Hymenopterous and Dipterous parasites were present on one estate in the Government of Kiev, Russia, in 1915. Averin** states that only a small number of larvae and pupae perished from the attacks of parasites and fungous disease in the Government of Charkov, Russia, in 1914.

Mr. Vinal stated at the conference that the percentage of parasitism in Massachusetts was found to be very small, only 15 out of 600 being parasitized. Of the parasites reared, there were four species of Tachinid flies (Diptera) and one (possibly two) of Hymenoptera.

Description.

The mature larva is about an inch long, flesh-colored, often somewhat smoky or reddish dorsally. Head dark-brown and flat. Each abdominal segment bears a transverse row of four dark colored spots, each spot surrounding a short stout spine. Just back of this row of spots are two smaller spots, one on each side, and a short distance from the median line.

The adults have a wing-expanse of about an inch in the male to an inch and a quarter in the female. The sexes differ greatly in color and markings and might easily be thought to be different species. The adults were described (though not originally) eighty years ago by Kollar, in his Treatise on Insects Injurious to Gardeners, Foresters and Farmers, the English edition of which was published in 1840, page 108. Except for the mention of the female

* Review of Applied Entomology, Series A, Vol. IV, page 208, 1916.

** Ibid, Vol. II, page 442, 1914.

being more rare than the male, a point about which I have no information, this description will serve to identify the species and is given here:

MALE. "The ground colour of the head, back, and anterior wings is brownish-grey, varying into purplish; on which yellow ochre-colored spots and markings appear in patches. The antennae and palpi are grey, the former serrated, the latter short, porrected (elongated), and pointed. The shoulders are generally light yellow ochre. The abdomen is grey, with whitish rings, the anal tuft brown mixed with grey. On the fore wings there is usually, but not always, an indistinct yellow, notched, transverse line, followed in the middle of the wings by a longish, cornered, yellow spot, and a second transverse line, very wavy, and more or less flowing into the veins. There are many yellow dust-like spots just above the grey fringes. The under wings are fainter; they have an imperfect, broad, yellowish-white band, which sometimes only looks like a large middle spot.

"The under side of all the wings is throughout dull brown, the markings on the upper side form a pale yellow band, and a middle spot of the same colour bordered with dark brown.

FEMALE. "Much rarer than the male, the yellow ochre is spread over its back and the whole of its upper wings; the transverse lines, on the contrary, are light brown; the two central spots are of the same colour. The border above the fringes is notched, watered-brown, and the fringes themselves are yellowish. The under wings have brownish-grey dust-like spots near the base; the broad faint middle band, as well as the border of the fringe, alternate yellowish light grey."

Both sexes, larva, pupa and injured corn stem are shown on plate XXX, b.

MEANS OF SPREAD.

The adults having the power of flight, even though not particularly attracted to lights would naturally extend their occupied territory somewhat each year. The present infested area in Massachusetts probably represents the natural spread of the pest from a single point since the insect was introduced several years ago. As the prevailing summer winds are from the Southwest, we should expect that it would spread further toward the Northeast than in other directions and this seems to the case.

There is great danger, however, that this insect may have been transported in celery, green sweet corn, seed corn on the ear, or in stalks or stover to more distant and widely separated points and that separate infestations may have been started there. The area infested in Massachusetts is a truck or vegetable growing center and green sweet corn is shipped northward, especially to the summer

hotels, in Maine, New Hampshire and Vermont. Larvae carried in this manner might readily emerge from the ears or stems, and enter the stalks of corn growing near by. There is not much shipping of green sweet corn toward the South, but the dried seed may be left on the ear and shipped anywhere, though I am informed that most of the seedsmen obtain their seed corn in shelled condition. Celery is commonly shipped.

Dried corn stalks or stover is used chiefly as fodder and not shipped very great distances, but according to Mr. Caffrey it is used to a limited extent as a packing material for heavy pottery, stone and glass ware, and of course may be sent anywhere and any distance. As the larvae hibernate in their burrows and often pupate there or in the crevices of packing boxes, there is great danger of the pest being transported in this way.

Quarantines.

On account of the possible danger of transporting this insect in ears of sweet corn, seed corn, or in corn stover the following quarantine was established:

State of Connecticut.
Office of
Agricultural Experiment Station,
New Haven, Conn.

September 20, 1918.

Whereas a very destructive insect known as the European Corn Borer *Pyrausta nubilalis* Hubner exists in the State of Massachusetts and threatens the corn growing industry of the country; and

Whereas there is great danger that this insect may be brought into this state by transportation of corn on the ear or parts of the plant containing the larvae or pupae from said State of Massachusetts into this State;

Therefore pursuant to the provisions of Section 2106 of the General Statutes it is hereby ordered that no corn on the ear, stover, or other parts of the corn plant (except the shelled dry kernels or cooked and preserved products or corn grown in other states passing through the State of Massachusetts in transit) shall be transported or moved or brought from the State of Massachusetts into the State of Connecticut, unless written permission therefor be first obtained

from the Director of the Connecticut Agricultural Experiment Station, which permission shall accompany each shipment.

This order shall take effect from its date.

E. H. JENKINS,
Director Conn. Agricultural Experiment Station.

Approved:
M. H. HOLCOMB,
Governor.

At the time of this writing the State of Vermont has issued similar regulations and the Federal Horticultural Board has placed a quarantine against the infested towns of Massachusetts. It is evident that these quarantines should be modified to include celery.

CONTROL MEASURES.

From the fact that the insect passes its larval and pupal stages entirely within the plant, it is evident that it must be controlled in some way other than by the use of insecticides. The best chance for control seems to be along the lines of cultural practice, the most important points being the disposal of the stalks and the destruction of the stubble, weeds and rubbish around the field which serve as a hibernating place for the larvae. These methods will not prove very effective unless carried out by every grower in the infested region. Hence co-operation is desirable and necessary in the control of this pest.

Disposal of Infested Stalks—Where the stalks are cut into short pieces and packed in the silo and there undergo fermentation, there is little chance that any individual can escape death. Probably few borers will escape if the green corn is fed to cattle or to hogs. The dry stalks or stover will not all be eaten by cattle unless cut up or shredded, but if this is done and and not too great a quantity is given at one time, it will be eaten and all insects destroyed. Where there are no cattle or hogs kept on the premises the stalks may be burned, buried under a foot or more of soil, or composted with plenty of manure and there should not be much danger of the borers emerging the following season. It should be borne in mind that the stubble also should be plowed under deeply, or dug out and gathered and buried or burned.

Destruction of Weeds and Rubbish—In the control of this insect it is extremely important to keep the field absolutely free from weeds, especially those which are attacked. This applies not only to the cultivated portion where the crop is grown, but also to the margins and uncultivated land adjoining. If such plants are allowed to grow they should be destroyed by gathering and burning, or by feeding to the hogs or composting them with manure in order to kill the larvae in them. The same treatment should be given the stalks of potato, tomato, bean or any other cultivated plants which grow near the corn and thereby become infested.

Probably it is only by the most persistent, thorough and universal practice of these methods that the European corn borer can be satisfactorily controlled.

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THE BEAN LEAF BEETLE.

Cerotoma trifurcata Forst.

In 1918, for the first time in many years the bean leaf beetle was reported as injuring beans in Connecticut. The writer observed this damage to string beans on May 29, in a garden at 1108 Whalley Avenue in New Haven. Though not very abundant, beetles could be found here and there feeding on the leaves, and a part of one row had most of the leaves perforated and ragged.

On June 2, the writer found these beetles at work on string beans in his own garden, though not sufficiently abundant to render spraying necessary. On June 11, they had increased somewhat in numbers, and there was evidence of moderate feeding upon the leaves which were injured as shown on plate XXXI, d.

This insect occurs throughout the eastern half of the United States and feeds normally upon native leguminous plants such as

bush clover or *Lespedeza,* tick trefoil or *Meibomia,* and hog peanut or *Amphicarpæa.* The adults feed upon the leaves of these plants and the larvae feed upon the roots or stems below the surface of the ground. It has also been recorded as feeding upon the leaves of cowpeas, soy beans and English horse beans. McConnell* records an unique form of injury to cowpeas, wherein the larvae devoured the nodules on the roots, thus destroying the organisms which enable the plant to obtain nitrogen from the air. The chief damage occurs in the Gulf States, but in certain seasons considerable injury results from its attacks further north. Injury to foliage has been reported from Indiana, Ohio. New Jersey, Delaware, Maryland and Virginia. *Cerotoma trifurcata* is a native American species which occurs from Canada southward to the Gulf of Mexico, and as far westward as Minnesota and Kansas. The Station collections contains adult beetles from New Haven, Hamden, Branford, and Windsor: no doubt the species occurs throughout the state.

The adult beetle shown on plate XXXI, c, is about 5 mm. in length, and varies in color from pale buff to dull red with black markings which vary greatly, the typical form having two large, more or less rectangular spots half-way and close to the inner margins of the wing-covers; a triangular spot at the base and a smaller one at the apex, both close to the inner margin; the outer lateral margin is bordered by a black band, which does not quite reach the apical spot. Head black, thorax buff, without markings. Antennal joints buff, tipped with black. Legs buff, with tips of middle and rear femora, and middle and rear tibiae, black.

This species is subject to great variation, specimens being found without black markings, while others have the markings confluent giving them a decidedly dark appearance.

The beetles appear as early as April in the South but in the North they do not attack the beans until June. They are usually found on the under side of the leaves and though their injury may be seen, on account of their position they often escape notice.

The eggs are oval, orange in color and are laid in the soil around and rather near the stem of the food plant in clusters of six or more.

Where only a few beetles are present, hand picking may be practiced, or insect powder may be dusted upon the leaves, but in case

* Journal of Economic Entomology, Vol. 8, page 261, 1915.

of a severe infestation, the foliage should be sprayed with lead arsenate, one ounce of the paste or one-half ounce of the dry powder in one gallon of water. Lead arsenate of course, should not be applied to string beans if the pods are nearly ready to harvest. As a rule the injury appears long before the pods are large enough, and in fact usually before the beans blossom. Where the beans are to be shelled and the pods discarded, there is no danger from the use of lead arsenate.

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INJURY BY THE RASPBERRY SAWFLY.

Monophadnoides rubi Harris.

On May 29, 1918, the Entomologist was called to examine a field of red raspberries, containing about an acre, on Osborn Avenue, north of Dyer St., New Haven. This field is situated on a knoll and slopes toward the north and east. Nearly all the leaves had been riddled by the green spiny larvae which were very abundant, nine being counted on a single leaf. Most of the larvae were nearly mature, consequently the damage had been done. Practically all of the older leaves had been eaten, but the new and tender shoots were uninjured. The owner who had just discovered the injury had attributed it to the small brown beetles, *Byturus unicolor* Say, which were also rather abundant on plants in certain parts of the field. As the owner desired to prevent any further damage he was advised to spray the field with lead arsenate, using two pounds of the paste in 50 gallons of water. The spraying was done immediately with a power sprayer but the season's crop had already been seriously injured.

Considerable material was gathered and brought to the laboratory, and on June 4, all larvae had gone into the ground to pupate.

The larvae are dark green, matching very closely the tint of the upper side of the leaf, covered with tubercles bearing lighter green forked spines, which are about the same color as the under surface of the leaf. Though the larvae usually feed upon the upper side, on account of the close resemblance in coloration they often escape notice, especially where the leaves have been riddled so that they show in shreds of both light green and dark green.

This insect has been observed and collected a number of times in Connecticut and was mentioned in the Report of this Station for 1908, page 846.

The raspberry sawfly appears to be a native American species, which has been mentioned in literature occasionally since the publication of Harris' "Entomological Correspondence" in 1846. It occurs in the Northern States and Canada from the Atlantic Seaboard as far westward as Iowa. In Connecticut, this insect has been collected or observed at New Haven, North Haven, Branford, and Stonington and doubtless occurs throughout the State.

The eggs are laid by the females on the under surface of the leaves usually near the mid-rib or the larger veins. Sometimes like those of the currant worm, they are placed in a row along the midrib but more often the female makes an incision and deposits the egg in the tissues of the leaf, between the two outer epidermal layers. The egg is white, oval in form, and less than one millimeter in length. The leaf tissue over each egg becomes dry and turns yellow giving the leaf a spotted appearance, which is quite characteristic of the attacks of this insect. At the end of a period varying from seven to ten days after being laid, the eggs hatch and the young larvae begin to feed upon the leaves, at first eating only the epidermal layer, but as they become larger they are able to eat entirely through the leaf until finally nothing remains but a net work of veins, as shown on plate XXXII, b.

About ten days is the length of the larval feeding period, when the larvae become mature and enter the ground to pupate. They remain in their pupal cells from June until the following spring and do not actually transform to pupae until March or April. The true pupa stage lasts only a few days and the adults emerge in Connecticut in May.

The full-grown larva is about 18 mm. or three-quarters of an inch long, with body leaf-green with lighter colored spines as shown

on Plate XXXII, a. The adult is a small black sawfly with yellow abdomen. It would not attract notice ordinarily.

There is only one brood each year and treatment by spraying with hellebore or lead arsenate is a simple matter if taken in season. But it is necessary to watch the plants during May because the feeding period is short and the bushes are often stripped before the larvae are known to be present.

All sawfly larvae are easy to kill, and fresh hellebore dusted upon the wet leaves or sprayed upon the leaves when not wet, at the rate of one ounce in two gallons of water, will prove effective.

Lead arsenate may be applied like the hellebore, either as a dry powder sifted or blown upon the leaves when wet with dew, or just after a shower, or it can be applied in the form of a spray. Two pounds of the paste or one pound of the dry powder to 50 gallons of water will be all the poison needed to destroy the larvae.

Lead arsenate should not be used late in the season when the fruit is nearly ready to harvest. If any treatment is needed at that time hellebore should be used. But there is usually no occasion for late applications as the larvae do the damage in Connecticut during the latter part of May. The spraying must be done soon after the plants blossom, and may be done even before they blossom to prevent defoliation.

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THE IRIS ROOT BORER.

Macronoctua onusta Grote.

From time to time the larva of this insect has been sent to the Station, accompanied by reports of injury to Iris beds, tunneling in the rootstocks, but not until 1915, did we succeed in rearing the adult. A brief note regarding the insect was published in the Report of this Station for that year (1915), page 189, and the adult was shown on plate XV, b. In 1918 the Iris Borer was again received and observed, and following a discussion by several correspondents in the Florists' Exchange a brief article was submitted

by the writer and printed in the issue of October 5th, Vol. XLVI, page 531, 1918, of that journal. The following paragraphs are from this article: "An adult in the Station collection was reared from a nearly mature larva collected July 30, 1915. This larva pupated and the adult emerged in October. Mr. A. F. Winn* observed the moth to lay eggs the latter part of September at Westmount, Quebec. in cracks near the base of the leaves of German Iris, and some eggs were deposited between the leaves where the edges overlap. Mr. Winn believes that in nature most of the eggs are laid underneath the edges of these overlapping leaves near the base and that the insect passes the winter in this manner.

"Mr. Henry Bird** of Rye, N. Y., states that the larva bores in the native Iris (*I. versicolor*), the adults emerge in September, and that the larvae are more highly parasitized than other species of Noctuidae which have come under his observation. Apparently Dr. Roland Thaxter† was the first to record the species from *Iris versicolor,* which he found at Kittery, Me. Mr. Arthur Gibson‡ records the rearing of several adults which emerged in September.

"Perhaps the most complete account of this insect which so far has been published, occurs in the 27th Report of the New York State Entomologist, page 52, 1912, by Dr. E. P. Felt. An illustration of the adult appears on plate 17, figure 3, of the report just mentioned. Dr. Felt also published a brief note in the 30th Report, page 71.

"From all of the observations and data gathered, it seems probable that the adults emerge and lay their eggs in the fall and that these eggs hatch the following spring. Of course it is possible that more than one generation occurs in Mr. ——'s latitude, or perhaps the eggs which he has observed as being deposited at the tips of the leaves, are laid by some other species. Here is a chance for careful investigation. It is hoped that some entomologist may be able to carry out such studies with a large amount of material in order to determine the exact facts in regard to the life history of this interesting species. Then we may more intelligently, discuss the subject

* Canadian *Entomologist,* Vol. 46, page 296.

** Journal N. Y. Entomological Society, Vol. X, page 215.

† Canadian Entomologist, Vol. 23, page 35.

‡ Ibid, Vol. 36, page 355, and 34th Report Ontario Entomological Society, page 49.

of remedies. In Connecticut, the injury is fairly common but occasional, and only a small amount of material can be found in any single Iris plantation. Most of the larvae which we have secured, fail to produce adults."

In some of the papers mentioned it has been recommended that the Iris leaves be removed and burned or the beds burned over in Spring to destroy the eggs. One of the correspondents of the Florists' Exchange claims that this will do no good because the eggs are laid in early summer, but apparently he is mistaken and has observed the oviposition of some other insect.

Both larva and adult of the Iris Borer are shown on plate XXXIII, a, and b.

GARDEN SLUGS.

Nearly every season inquiries come to the station, sometimes accompanied by specimens of injury to garden or greenhouse plants by slugs. Slugs are not insects though they devour the leaves of plants in much the same manner as insects. They are really mollusks and are closely related to the snails, though not provided with shells. They feed at night often greatly injuring or totally destroying tender foliage, and are especially troublesome around cold frames, greenhouses and in old gardens. Wherever they crawl they leave a trail of slime or mucus which often disfigures the plants, and by means of which they may be traced to their hiding place usually under boards in walks or under rubbish in dark and damp places near the ground. The slugs gnaw large irregular holes in the leaves and sometimes cut off the tender stems in much the same manner as some of the noctuid larvae, especially climbing cutworms: but their injury may be distinguished by the trail of mucus.

Food Plants.

Slugs show a preference for lettuce, but have been recorded on many vegetables, including also celery, parsnip, turnip, carrot, beet, cabbage, onion, leeks, peas, beans, melons, potato, tomato, sweet potato and strawberry. They also feed on violets, ferns, geraniums and doubtless many other plants in garden and greenhouse, and also the common grasses and weeds. They are particularly fond of stored tubers, and cause considerable injury to both potatoes and sweet potatoes when stored in damp cool cellars. Celery when

banked with earth for blanching is often seriously damaged. According to White, slugs are fond of sour milk and raw beef,* and cause much damage to mushrooms grown in pits and cellars.

Life History.

The translucent light yellow eggs are laid in masses of 50 to 100 held together by a light-colored substance usually in damp places underneath flower pots, decaying boards, stones or clods of earth. The young slugs feed upon such materials as may be at hand, and remain four or five weeks together as a colony near the egg mass. They feed at night and remain during the day in a moist dark place.

It is not known just how long a period is required for a slug to reach full development but this probably varies with the species. White† states that in 30 days the young reached a length of an inch in captivity while it takes six months for them to reach a size of about two inches in a heated greenhouse.

It is believed that in winter, slugs go into the ground below the frost line, into pits, cellars, drain pipes, etc.

In heated places like hot beds and greenhouses slugs will continue to breed throughout the winter.

The Spotted Garden Slug.

Though there are three species of slugs found in the United States, the largest species known as the spotted garden slug *Limax maximus* Linn. is the one with which the writer is the most familiar as he has been troubled by it in the cold frame, where lettuce and various other seedling plants were injured. This slug has been known to reach a length of seven inches, when fully extended but, the specimens which commonly are seen are usually three or four inches long or less. The younger forms are a uniform gray in color, but the older and larger individuals are distinctly black-spotted. Back of the head is a shield-like covering or mantle and back of this mantle there are three rows of black spots extending to the rear end of the body. When crawling, two fleshy protuberances or horns are extended forward from the head, each bearing a black eye at the tip. This slug is shown in figure 13.

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* Farmer's Bulletin 959, U. S. Department of Agriculture, 1918.

† Ibid.

Control Measures.

The common toad devours slugs but there are said to be few natural enemies.

The application of arsenical poisons to plants is not wholly satisfactory, but may serve to protect the plants, as the slugs seldom feed upon poisoned foliage. On plants to be eaten like lettuce, of course poisoning would be out of the question. Potatoes, baked or boiled, may be poisoned with arsenic and distributed at the rate of one tuber in about two square feet of space in the infested area; some of the slugs will feed upon this bait.

As a rule a bed may be protected by surrounding it with a layer of air-slaked lime but soot, fine coal ashes, road dust, or in fact any inexpensive dry powder will answer the purpose. A sprinkling of common table salt upon one of these slugs will cause almost instant death.

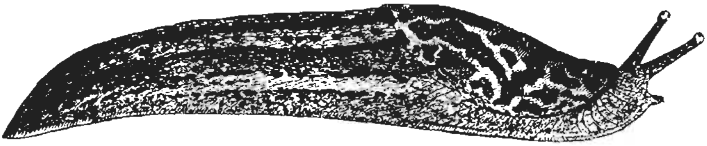

Figure 13. Spotted garden slug, natural size. (After Kingsley, Riverside Natural History.)

Much can be done to control this pest by cleaning up all decaying vegetation around the plants. All plants should be carefully examined and slugs removed before transferring to the greenhouse from the field or frame. All old boards and flower pots should likewise be inspected before they are carried inside.

In greenhouses slugs are often hunted and destroyed at night by means of a lantern or flash light. In the daytime the trail of mucus leads to their hiding places where they can easily be destroyed.

The following account of the habits of slugs is copied from The Riverside Natural History, Vol. I, page 317, and is still of interest:

"The slugs are chiefly nocturnal, and this fact accounts for the few ordinarily seen, although there may be thousands about. In the daytime they secrete themselves under boards, fallen trees, etc., where there is at least partial darkness, but at night they come out to feed. They do a great amount of damage in gardens, as they feed largely on vegetation, although they are not averse to an animal diet. Since they hide

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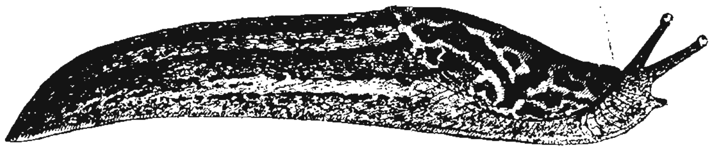

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"The slugs are chiefly nocturnal, and this fact accounts for the few ordinarily seen, although there may be thousands about. In the daytime they secrete themselves under boards, fallen trees, etc., where there is at least partial darkness, but at night they come out to feed. They do a great amount of damage in gardens, as they feed largely on vegetation, although they are not averse to an animal diet. Since they hide

themselves during the day, the damage they occasion is usually attributed to birds, and the larvae of insects, but the presence of slugs can usually be recognized by the presence of streaks of glistening slime in the neighborhood. Most of the terrestrial pulmonates are able to secrete a mucus from their body, and in some there are special pores for its emission. In the slugs this capacity reaches a great development, and as they crawl along they leave a streak behind them, which, on drying, produces the glistening marks referred to. This secretion of mucus is to a certain extent defensive, and when the animals are irritated the amount is greatly increased. This fact gives us a simple method of checking their ravages, which is to sprinkle coal-ashes around the plants which it is desired to protect. The fine grit of the ashes irritates them, and they pour out the mucus to such an extent that they are exhausted, and besides, since it rapidly hardens on exposure to the air, they are soon rendered prisoners.

''This secretion of mucus is used in another way. Slugs frequently climb trees in search of fruit, and when through feeding they take a quicker method of descending than their ordinary snail's pace. The foot pours out a lot of mucus, which is passed along to the posterior end. This mucus is then attached to the limb on which the animal is, and then the slug casts itself loose. Its weight draws the mucus out into a fine thread, and more being secreted, the slug lets itself down after the fashion of a spider, with this exception; it has not the power of returning to the point of support. The power of forming a thread has been observed in almost all the American species, at least when young; but some of the larger forms, when adult, are too heavy to trust their weight to such a slender support.

''We have spoken of their ravages in gardens, but in America they have not yet become such a pest as in Europe. There they are classed along with caterpillars, locusts, and rats, and a war of extermination is waged against them. In olden times the power of the church was invoked against them, but prayers and anathemas failed to cause their extinction, or in fact any appreciable diminution of their numbers. There is another aspect which should not be passed by without mention. Slugs have long been supposed to have medicinal qualities, the rudimentary shell being regarded as especially efficacious. This belief can hardly be regarded as extinct, as Mr. Binney says that ''during the year 1863, a syrup of snails was prescribed to members of my family, by two regular French physicians in Paris.'' During the middle ages, when superstition ran riot, of course they were much more highly esteemed. The shell was regarded as an amulet, protecting the wearer against certain diseases and witchcraft, while the liquid obtained by their distillation was used to improve the complexion. In Europe they are eaten, but in America neither dietetic nor magic qualities have been assigned to these loathsome appearing animals.''

MOSQUITO WORK IN 1918.

By B. H. Walden.

In 1918 no new mosquito work was carried out under the law. All of the drainage work which had been approved by the Director of the Station was maintained as provided by the statutes.

One of the most severe storms in years occurred during the fall of 1917 and caused much damage to shore property including the mosquito work. Culverts were washed out, tide gates were damaged and outlets to ditches in many cases were filled up.

Owing to the scarcity and high cost of labor only such work as was considered absolutely necessary was done. The ditches were gone over and all obstructions removed and the ditches cleaned where it was necessary to secure good circulation. Throughout the early part of the season the tides were usually high and produced considerable breeding especially before the first clean-up work was completed, but during the remainder of the season conditions were much more favorable for mosquito control. Had the latter part of the season been wet, however, much additional work would have been necessary to prevent breeding in several sections. These will require special attention next spring.

Early in the spring the selectmen of Madison, Guilford and Branford proposed that they furnish the men for the mosquito work in their respective towns, as they could secure men cheaper than the state could hire them. One reason for this being that the men could be engaged for the season and employed on other town work when not needed for mosquito maintenance whereas the State could only employ them temporarily during practically the same season that there is a special demand for laborers on work which is more desirable than mosquito work. This plan was carried out with more or less success in these three towns, payment for the men's time being made to the town or directly to the men according to the arrangement made.

Madison.

The storm in the fall did considerable damage to the culverts along Madison Beach. The large culvert of West Wharf Road was entirely removed. While this culvert remained in place during the winter of 1917 it did not seem advisable to replace it with one of similar construction or go to the expense of building a more per-

manent structure this season. The outlet was therefore kept open by cleaning out the sand as required during the season. The outer sections of two other culverts were washed away and one at the east end of the beach had the upper end buried by three to four feet of sand deposited on the marsh for a distance of ten or twelve feet. It was necessary to put an additional section on the upper end of the culvert. The ditches on the marshes were maintained in a satisfactory manner.

GUILFORD.

A proportionately large amount of work had to be done on the Leete Marsh north of Shell Beach. The new outlet ditch as well as some of the old ditches required extensive cleaning. The tide gate at the outlet was damaged by the winter and required repairing. A new tide gate was built on the trolley culvert at the outlet of Great Harbor Marsh. After much delay in securing a contractor to build the gates, they were completed the first week in August. The frame work of the structure was made of 10″ x 12″ and 12″ x 12″ yellow pine with the joints treated with Asphaltum. The two gates 4′ x 4′ are of 2″ cypress plank, double thickness, the outer planks placed vertically and the inner planks horizontally. The gates are hung from the top with specially constructed hinges of heavy strap iron connected with a five inch link or ring. This style of hinge prevents any binding and allows the gates to readily settle into place with the pressure of the water. Above the gates sheathing of 3″ planking extends to above the high water mark.

BRANFORD.

In Branford, a local contractor agreed to furnish laborers for the maintenance work but owing to the prevailing conditions he had trouble in hiring men for his regular work. Several attempts without success were made by the writer to engage men at a reasonable figure. Consequently less work was done in Branford, than in the other towns. The ditches, however, were all gone over and a small amount of extra work was done on the Hotchkiss Grove Marsh and the tide gate at the outlet.

The old tide gates on the Branford River at Hobart's Bridge which were built and maintained by a meadow association were destroyed by the storm in the fall. The Director of the Station was called upon under the State law to build new gates. Estimates

were obtained and it was found that owing to the small amount of money already expended on maintenance work there would be an amount sufficient to build new gates of similar construction as the old ones. There are two bridges across the river, the openings being 28 feet and 18 and one half feet respectively. Four gates were placed on the larger opening and two gates on the smaller. Each gate consists of a frame with single two-inch planking. In order to allow small boats to pass up and down the river the gates are hung from the sides and swing on wooden rollers which set into a mud sill at the bottom and a heavy stringer at the top, and are arranged in such a way that they can be readily removed during the winter. While this style of gate would not be suitable where it is necessary to keep out as much water as possible, it appears to keep out sufficient water in this case to prevent the meadows above from flooding.

East Haven.

The maintenance work on the small ditched area in East Haven was done by Mr. Draper who had charge of the New Haven Work.

New Haven.

Mr. J. W. Draper, who has been employed on the New Haven mosquito work for the past two seasons was engaged during 1918. Additional help was obtained in the spring when the ditches were first cleaned. The large tide gate at the Congress Avenue Bridge on the West River was badly damaged in the fall, and the temporary repairs made by the city were not adequate to prevent the water from flooding the meadows above. The meadows were under water a large part of the time and the vegetation was killed on most of the area up as far as the Chapel St. Bridge. In some cases trees were killed by the flooding. While there was very little mosquito breeding in this area, much damage has been done to the ditches cut in 1917, and the existing conditions have produced one of the most unsightly areas around New Haven. The only solution is to build new tide gates to replace the old ones.

Orange.

The mosquito drainage work in Orange has been cared for by the town, under the direction of Dr. Charles D. Phelps.

Fairfield.

The work in this town was done by Mr. Nicolas Matinck who has been employed on the mosquito work for the past two seasons. Some annoyance from mosquitos, principally fresh water species, was experienced early in the season. This was largely due to favorable breeding condition and the emergence of adults before Mr. Matinck could complete the first clean-up of the extensive area.

ENTOMOLOGICAL FEATURES OF THE SEASON.

Following an extraordinarily severe winter which killed practically all peach buds, except in a few cases along the shore, and almost killed many peach and apple trees in Connecticut, the season of 1918 opened early and there was a fairly good bloom on apple and pear trees. At blossoming time the weather was fair though cold, and there was a good prospect for a set of fruit. Later, however, many growers were much disappointed at the light crop in most sections of the State. In certain localities a good crop was obtained, but generally there was a very light set of fruit, probably due to the absence of bees to pollinate the flowers. At blossoming time, though the weather was clear the temperature was very low, and bees were scarce. Many bees, especially honey bees, winter-killed and were much fewer than normal early in the season. This is probably likewise true of the small native bees of *Andrena, Halictus* and allied genera which ordinarily visit and pollinate the blossoms. On account of the low temperature, those bees which did survive the winter could not work the flowers, and these two factors seem to be responsible for the poor set of fruit.

Apparently the season was fully two weeks ahead of the normal as regards time of bloom, etc., and such seeds and plants as do not require a high temperature could be put into the ground. High temperature plants like tomatoes, cucumbers, squashes and melons were not planted out much earlier than the average. It remained cool and moist during May and June, then there were a few days of hot dry weather. Potato vines wilted, dropped to the ground and dried up. This was at first thought to be due to insects, then bacteria or fungi but was probably physiological, due chiefly to a lack of fertilizer, or moisture, or both.

Aphids were not troublesome in the orchard but in the vegetable garden they caused much damage particularly on potato, tomato, spinach, turnip, cabbage and nearly all kind of plants.

The Colorado potato beetle was present in usual numbers, and the three-lined potato beetle, clavate tortoise beetle and blister beetles were more abundant than usual in potato fields.

In orchards the false red-bug caused damage in certain sections of the State particularly in Fairfield and New Haven Counties. Its injury was also conspicuous in the dwarf apple orchard at the college at Storrs, at the time of the field meeting August 9.

The tent-caterpillar was almost entirely absent from apple and wild cherry trees throughout the State.

The brown-tail moth was also hard to find.

Peach borers were unusually abundant and troublesome in many orchards late in the season.

Scouting for the Oriental Peach Moth shows it to be present in the State and also calls attention to the presence of the peach twig borer *Anarsia lineatella*.

The squash borer was present in usual numbers during the season.

The elm leaf beetle seems to be on the increase and tussock moths were common on fruit and shade trees throughout the State.

There was some injury from white grubs and wire worms, and the stalk borer and corn ear worm have attacked corn in certain localities.

The gipsy moth has apparently not been distributed by windspread as in 1913 and 1916, though a few additional towns have been found infested. In the older and worst infested towns the number of infestations and number of egg-masses are both less than a year ago.

Flea beetles were very abundant and did much damage to vegetable crops, especially to potatoes, tomatoes, cucumbers and Chinese cabbage.

The European House Cricket *Gryllus domesticus* Linn. was discovered in the State at Shelton where one dwelling house was infested.

More detailed information regarding most of these insects will be found in the pages of this report.

MISCELLANEOUS INSECT NOTES

Larva on Tartarian Honeysuckle;—On June 6, 1918, a bright green larva tapering sharply towards both ends and with a black median stripe, was collected in New Haven on Tartarian Honeysuckle, by Mr. F. J. Reveley, supervisor of war gardens. On July 18, the adult emerged and proved to be an undescribed species of *Harpipteryx.*

The Clavate Tortoise Beetle, *Coptoclycla clavata* Fabr:—This insect was unusually prevalent in Connecticut on potato in 1918, being received from Clinton, Guilford, Meriden, Monroe, Plainville and Shelton and observed in many other places. An illustration will be found on Plate XVI, a, and a brief account of the life history of this insect on page 110 of Bulletin 208, which is a part of the annual Report of this Station for the current year, 1918.

Abundance of Potato or Cucumber Flea-Beetle, *Epitrix cucumeris* Harris:—This insect was extremely abundant on potato throughout the State and in New Haven attacked potato, tomato, cucumber and Chinese cabbage. The beetles persisted through May and June in spite of repeated sprayings. In July they were still present but not as abundant. As this insect has been discussed in Bulletin 208, page 103, which is a part of the annual Report of this Station it can only be mentioned here.

The Rose Chafer, *Macrodactylus subspinosus* Fabr:—This insect was somewhat less troublesome than in 1917, though it was present and did considerable damage. The adults appeared much earlier than usual, as Mr. Brown observed them at Clinton, June 1. The Entomologist collected two adults, June 2, in his garden. The earliest previous record was June 9, and usually the beetles appear about June 12.

Salt Marsh Caterpillar Feeding on Bean:—The Entomologist collected a hairy caterpillar August 24, 1917, feeding on bean in Westville; it was taken to the insectary, and in due course of time pupated. On May 25, 1918, a male moth emerged and proved to be *Estigmene acræa* Drury. The larva is called the "salt marsh caterpillar."

Abundance of Three-lined Potato Beetle, *Lema trilinata* Oliv:—This insect often known as the "old fashioned potato beetle" was more abundant throughout Connecticut in 1918, than I have

ever seen it during a residence in the State of nearly 25 years. It appeared early in June and fed for about a month. An account of its life history was published in Bulletin 208, page 109, with illustrations on plate XV, which is a part of the annual Report of this Station. Of course it can be controlled like the Colorado potato beetle by a spray of lead arsenate.

Birch Leaf Skeletonizer, *Bucculatrix canadensisella* Chamb:—This insect was very abundant in Connecticut in 1910 and was described in the Report of this Station for that year, page 701. Soon after it began to subside, and for the last five or six years has not been noticeable, but in 1918 the larvae were observed in New Haven, feeding upon the leaves of paper birch. We may fairly expect this insect to increase in abundance for the next few years, and all choice shade trees should be sprayed with lead arsenate to preserve their foliage.

Leaf-Tyer on Rose:—In the writer's garden in May 1918, small caterpillars were very abundant on some of the rose bushes tying together nearly all the leaves. Certain plants were almost defoliated. Specimens were gathered May 23, and placed in the insectary. On June 15, five yellowish moths had emerged. The wing-spread is about half an inch, the forewings are pale lemon yellow marked more or less distinctly with transverse orange bands. The species is *Tortrix albicomana* Clem.

Schizura unicornis on Hickory:—On July 26, 1917, Mr. Zappe collected a small larva of the genus *Schizura* feeding on hickory in New Haven. More material was gathered July 31 and placed in the breeding cages. Dorsal portion of thoracic segments black; first abdominal segment has a horn with two projections or tubercles on it; anal segment has a horn bearing two hairs; both segments in front of the anal segment have white notches forming a triangle. On May 28, 1918, an adult female emerged, which proved to be *Schizura unicornis* S. & A.

The Saddled Prominent in Litchfield County:—Specimens of the Saddled Prominent *Heterocampa guttivitta* Walker were collected in Norfolk in 1917 by men of this Station working on the pine blister rust. The caterpillars were abundant and feeding on the leaves of the deciduous forest trees in Norfolk and vicinity. This insect was well distributed in 1917 but in 1918, it was even more abundant in certain localities and woodland areas a half-mile square were stripped by them. The trees eaten were maple

beach and birch. During September the writer was informed by Dr. H. T. Fernald of Amherst, Mass., that the Saddled Prominent had defoliated large areas of deciduous forest in 1918 in Berkshire County, Massachusetts.

Absence of Tent-Caterpillar:—The tent-caterpillar *Malacosoma americana* Fabr. which was so very abundant in 1913, 1914, and 1915, and since then has been waning was almost wholly absent in 1918. Mr. Brown who traveled about the state all summer searching for the Oriental peach moth reported on June 3, having seen four tent-caterpillar nests, one in his orchard in Clinton and three in Fairfield County. Mr. Stoddard of the botanical department, reports seeing one nest in Norfolk, and Mr. Davis of this department saw a few nests in Windham County. Two nests were also reported from Woodbridge. Apparently the tent-caterpillar is now at its lowest ebb and is being held down by its numerous parasites and other natural enemies. In a few years it may be expected to again become abundant.

An Orchid Weevil in Connecticut:—On December 14, 1917, some small black snout beetles were received from the greenhouses of Morton F. Plant at Eastern Point, Groton, said to be causing injury to orchids. Mr. Q. S. Lowry visited the place and collected more material. The species was identified as *Diorymellus laevimargo* Champ., and is only about 2 mm. long and 1 mm. broad and is black and shining. The beetles feed upon the leaves, flower-stalks and pseudo bulbs of *Cattleya* and are said by growers to injure the flowers. This weevil is a native of Central America and has been recorded by Mr. H. B. Weiss as occurring in orchid houses in New Jersey*. No recommendations regarding control measures can be made at this time, though in some houses the men are sent through to collect all the beetles that they can find. This weevil is shown on plate XXXI, b.

Chamyris cerintha Feeding on Privet:—On September 19, 1916, Mr. Q. S. Lowry collected in Stratford a striking caterpillar feeding upon the leaves of California privet. This larva had brown thoracic segments, abdominal segments black with creamy white lines on the middle ones. Segments very distinct. Head black. Anal pro-legs very long. Larva somewhat hairy. On September 28, the larva escaped from the breeding cage, but was found

* Entomological News, Vol. XXVIII, page 27, 1917.

boring into a piece of board. This piece of wood was placed in the breeding cage and the larva bored into the end of it and spun a fine silken cover over the top and pupated. The adult emerged July 20, 1917, and proved to be *Chamyris cerintha* Treit. This noctuid moth has a wing-spread of about one and one-quarter inches, is white with fore-wings prettily marked with small black spots near base and apex and wavy transverse bands of reddish brown, olive green and bluish gray. The larva is said to feed upon plants of the family Rosaceae.

White Woolly Larvae on Hickory:—On July 6, 1918, specimens were received from Mr. W. A. Muirhead of the Street Department of Hartford, of white woolly larvae feeding upon hickory leaves. The same species on English or Persian walnut was sent in from Meriden in 1917 by Mr. Harry L. Johnson, and Mr. Lowry collected it on Butternut in New Haven. This insect is *Erythraspides caryae* Norton, first described from Farmington, Conn., by Mr. Edward Norton who has placed it in both the genera *Mononphadnus* and *Selandria.* The larvae feed on the under side of the leaves. They are nearly an inch long, green, but their bodies are covered with long wool-like material obscuring the body color. It is sometimes called the "Butternut Woolly Worm" and usually appears in July. There is only one brood each year. The adult is a small-sized sawfly with black body, rufous thorax and white legs; wings are somewhat infuscated. The species is rather rare and is mentioned here because it is noticed more often as a curiosity than as a pest.

Chrysanthemum Gall Midge *Diarthronomyia hypogæa* Loew; This European insect was first reported in the United States by Dr. E. P. Felt,* State Entomologist of New York, who had received specimens from Prof. R. H. Pettit, of the Michigan Agricultural College, collected at Adrian, Mich. Since that time this pest has been recorded from California, Oregon, Michigan, Ohio, New York, Pennsylvania and Connecticut. It does not yet occur in every greenhouse where chrysanthemums are grown, but it is found in many of them. This pest is now being investigated in Connecticut, especially as regards control measures. The adult, a small two-winged fly lays eggs between the hairs of the leaves or stem particularly of the new shoots, and each larva forms a gall on the leaf, flower sepal or shoot, transforming in from 40

* Journal of Economic Entomology, vol. 8, page 267, 1915.

to 50 days within the gall. Several generations may occur in a season in the greenhouse. A thorough spraying every few days with nicotine sulphate solution (1-500) and soap is said to kill the emerging adults and a large proportion of the eggs. Mr. Zappe is now conducting tests for the control of this insect. Infested leaves are shown on plate XXXVI, b.

Calosoma sycophanta Linn;—This large European ground beetle was introduced into the United States because both larvae and adults devour gipsy moth caterpillars. It has been present in Massachusetts for twelve years and colonies have been planted in the adjoining states infested by the gipsy moth. So far as known this beetle has been planted in Connecticut only at the following points by the gipsy moth force:—Stonington, 1914; Thompson, 1915; Killingly, 1917. In 1914, a year before the planting of the colony in Thompson, one male adult was found in that town by a gipsy moth scout and sent to the parasite laboratory at Melrose Highlands, Mass. The species had evidently spread into Thompson from Massachusetts or Rhode Island. On May 24, 1915, Mr. Harry L. Johnson of South Meriden captured a specimen near his home, at least 40 miles in a straight line from any point where liberated in the gipsy moth territory. Few recoveries have been made in the vicinity where liberated but the species seem to have become well distributed, as in 1918, gipsy moth employes observed this insect in Thompson, Putnam and Plainfield: Mr. A. B. Champlain reports it from Old Lyme: an adult was received from Darien July 13: Mr. K. F. Chamberlain employed as an assistant in this department, collected a specimen in New Haven, July 29, 1918, and saw one or two others badly crushed upon the sidewalk.

The Stalk Borer in Corn *Papaipema nitela* Guen:—Every season a number of specimens are received from various sections of the State, of a larva boring in herbaceous stems. Sometimes it is potato or tomato, sometimes dahlia or lily. It has usually been easy to recognize the pest as the stalk borer *Papaipema nitela*. During 1918, however, this insect was received seven times from Greenwich, New Haven, Guilford, Litchfield and Bristol, and in each case it was attacking corn. The larvae begin to feed on the leaves at the whorl before the stalk shoots up, and on account of this habit it was thought by some to be the army worm. A little later these larvae tunneled in the stalks and some corre-

spondents mistook this insect for the European corn borer (see page 316) which has not yet been found in Connecticut though suspected a number of times, and which may occur here. The stalk borer has already been mentioned and illustrated in Bulletin 208, page 111 (plate XVIII, a and b) which is a part of the Annual Report of this Station for 1918. As a rule it is only a stalk here and there which is attacked. There is no good remedy other than destroying the infested stalks when noticed. One employee of the Station grows dahlias, and claims that by watching the plants carefully he can detect the borers before the plants begin to wilt. By injecting a thin mixture of lead arsenate and water, into the burrow by means of an oil can he kills the larva without further injury to the stalk.

The Poplar Girdler *Saperdacon color* Lec. var. *unicolor* Joutel:—This long horned beetle has long been known as a borer in small stems and branches of poplar and also certain small species of willows. A swelling or gall is formed around the burrow as is shown on plate XXXIV, b. The beetles emerge and the eggs are laid in May, and the accompanying illustrations show (plate XXXIV, a) the peculiar triangular areas marked out by incisions cut into the bark. A white oval egg is deposited at the apex of this area as shown on plate XXXV, a. The grub or larva hatching from this egg at first eats out a cavity under the bark as shown on plate XXXV, c, but later makes a transverse tunnel which partially girdles the twig or branch. In order to heal these wounds, the growth is rapid and forms enlargements or galls at the points of injury. The adult beetle is about one-half inch in length, and is black with closely appressed gray or yellowish-gray pubescence: antennae are black annulated with gray. This beetle is shown on plate XXXV, b. The variety was described by L. H. Joutel in Bulletin 74, New York State Museum, page 74, 1904. Dr. Felt has included *S. concolor* in his "Insects Affecting Park and Woodland Trees," page 474, 1906, but does not mention the variety *unicolor*. The type is supposed to be of western origin and the form occurring in the Eastern States is considered as variety *unicolor*. The beetle shown in the illustration was collected from the injured twigs in New Haven. There is only one generation each year, and the insect pupates and passes the winter in the burrows inside the twigs.

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The Elm Leaf Beetle:—This insect has been rather scarce for several years in the shore towns of Connecticut and in some places spraying was discontinued. In 1913 and 1914 this pest was prevalent in some of the towns of Litchfield County especially at the higher altitudes of 1,000 feet or more, and stripped the trees in some cases. Spraying was then inaugurated in some towns to forestall further damage. In 1917 this beetle was quite abundant in Fairfield and many trees at Greenfield Hill in that town were defoliated. Additional injury was noticed in Manchester and Saybrook.

In 1918, adults were abundant in attics in Greenwich, and injury was reported from Goshen and West Haven. The entomologist visited West Haven on July 17th and in company with Mr. T. J. McGinness examined the elm trees on the green. Several large trees near the corner of Main Street and Campbell Avenue had been badly eaten and the leaves were falling. Several branches broken off in a thunder storm showed the work of the larvae, the leaves being badly riddled. The larvae were descending the tree trunks at this time, and were very dark in color—so much so, in fact, that we suspected them to be another species, which has occasionally been found on elm and since described as *Altica ulmi* Woods.* Consequently larval and pupal material was gathered and taken to the laboratory, but when the adults began to emerge on July 26, it was found to be the old offender, *Galerucella luteola* Mull., the elm leaf beetle. The larvae when gathered were uniformly dark gray, and did not show the broad yellowish dorsal stripe. Pupae could be gathered by the pint at the base of the trees.

On August 15, the entomologist appeared by request before the Board of Selectmen in West Haven, and explained the life history of the insect and the advisability of spraying the trees next season. This meeting resulted in an increased appropriation for the care of the trees, large enough to spray them properly in 1919.

A Tip Borer in Garden Physostegia:—On June 14, an amateur gardener living on Huntington Street near the Station, brought to the laboratory specimens of the terminal portion of the herbaceous

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* Bulletin No. 273, Maine Agricultural Experiment Station, page 182, 1918.

stems of a cultivated species of *Physostegia,* which had been attacked by some insect causing the shoots to wilt. On examination a small greenish yellow larva, evidently a tortricid was tunnelling inside the stem. The egg was probably laid on leaves or stem and the larva first begins to feed in the tips of the unfolding leaves, then tunnels downward into the stalk. In no case had it descended more than three inches. This causes the tips to wither and there were wilted tips on every bunch of *Physostegia* stalks in the garden, though there were some stalks in each bunch not affected. A visit was made to the garden and fully two-thirds of all shoots in each clump were infested. Some material was gathered and placed in the rearing cages. On July 9, a small purplish brown moth emerged. This has been identified by Mr. Heinrich of the Bureau of Entomology as *Olethreutes hebesana* Walk. The larvae is about 10 mm. in length and 1.5 mm. in thickness; body greenish-yellow, head, legs and cervical shield, black; a few scattered lateral hairs borne on tubercles. Adult, wing-expanse about 13 mm. (one-half inch), fore-wings, dark purplish-gray or brown marked with black and light brown spots. An irregular spot on costal margin, the basal portion mottled with purple and black, and the distal portion mottled with brown and black. Rear wings, fringe and under surface of both front and rear wings uniform dark brown. This moth is shown on plate XXXI, a. No control measures can be recommended other than destroying the infested shoots in June.

A Rare Moth Attacking White Pine:—On October 17, 1917, larvae feeding on white pine were received from Miss L. C. Alderson, Greenwich. These larvae live in silken tubes extending through a globular mass of their droppings, the mass being two inches or more in diameter. A brief description of the larva follows: Length about one inch, light brown or tan with four narrow, black or dark brown longitudinal stripes, the middle ones being broader than the lateral ones; hair lines in the transverse sutures between segments and also irregularly arranged. Head light brown marked with black or dark brown patches. Legs and prolegs light brown unicolorous with ventral surface. Scattered hairs are borne on the head, and dorsally, ventrally and laterally on each segment. On June 19, 1918, an adult emerged, which has been identified as *Tetralopha robustella* Zeller, a species reported from Florida, Texas and Colorado. The species described

as *diluculella* by Grote is now considered as a synonym of *robustella*. The moth has a wing expanse of about an inch, of a general grayish-brown color, slightly more than a third and less than half of fore-wings at base, dark brown; beyond this is a broad transverse band of pearl gray with dark discal dot near center; apical portion grayish-brown, lighter than base and nearly uniform with color of rear wings. Under surface nearly uniform grayish-brown, the rear margins of fore-wings being somewhat lighter. No attempt has been made to work out the life history of this species. Both larva and adult are shown on plate XXXVI, a.

NOTE REGARDING AUTHORSHIP.

For bibliographical purposes, all matter in this report (Bulletin 211) should be credited to W. E. Britton except where otherwise indicated.

ILLUSTRATIONS.

All plates are from photographs. Plate XXIII, by W. O. Filley; Plate XXIX, a, after Quaintance and Wood, Bureau of Entomology, U. S. Department of Agriculture; Plate XXX, a, after W. C. O'Kane, New Hampshire Agricultural Experiment Station; Plate XXXIII, a, by K. F. Chamberlain; Plates XXI, XXII and XXIV by W. E. Britton; All others by B. H. Walden. Figures 7 and 12 were prepared by Mr. Walden from maps; figures 8 and 9 after Wood and Selkregg, figures 10 and 11 after Marlatt, Bureau of Entomology, U. S. Department of Agriculture; figure 13 after Kinglsey, Riverside Natural History.

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a. Spraying apple orchard with automobile truck power sprayer. Woodstock.

b. Another view in apple orchard, spraying with automobile truck power sprayer. Woodstock.

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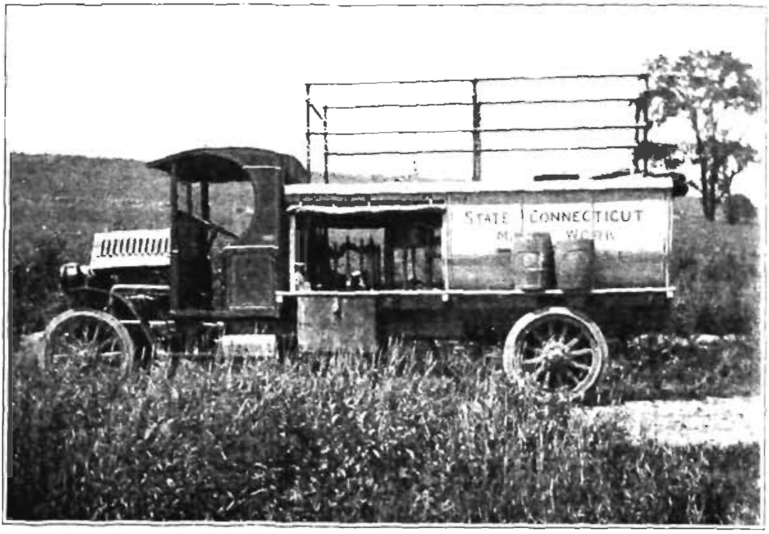
a. Spraying apple orchard with automobile truck power sprayer. Woodstock.

b. Another view in apple orchard, spraying with automobile truck power sprayer. Woodstock.

GIPSY MOTH WORK.

PLATE XXII



a. Automobile truck power sprayer.

b. View in woodland, Wareham, Mass., showing stripping by gipsy moth caterpillars, Photographed July 12, 1918.

GIPSY MOTH WORK.

View in stripped area, Wareham, Mass., at time of the visit of the Connecticut Finance Board, July 12, 1918.

GIPSY MOTH WORK.

PLATE XXIV.

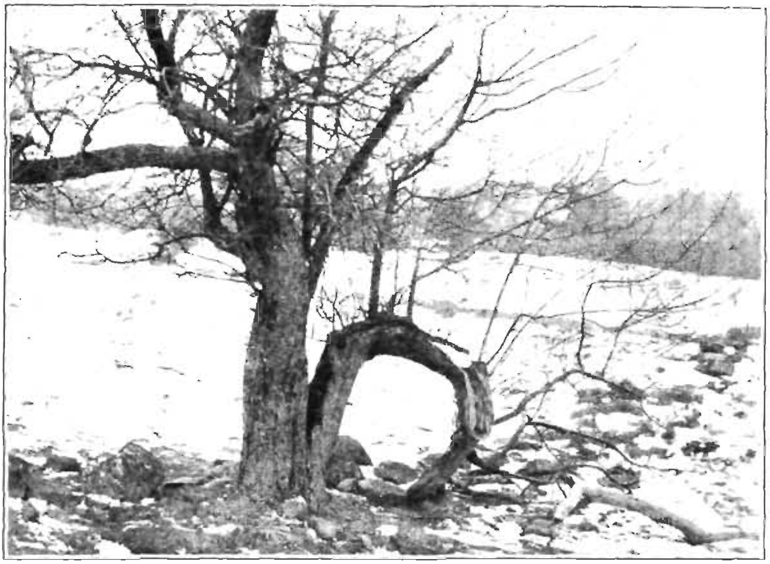
Scouting for egg-clusters. This large white oak growing in the open had several egg-clusters. Woodstock.

GIPSY MOTH WORK.

a. Roadside scouting in Thompson.

b. Scouting in woodland near road, Thompson.

GIPSY MOTH WORK.



a. Old apple tree in Killingly, with hollow portion infested with egg-clusters.

b. On cutting off the hollow portion of the trunk it was found to contain 118 egg-clusters: 20 of these were old ones, and 98 were new.

GIPSY MOTH WORK.

a. This pasture white oak was infested, 12 old and 95 new egg-clusters being found. Killingly.

b. View showing the men scouting in an apple orchard. Thompson.

GIPSY MOTH WORK.

a. Heating water, slicing and melting the soap for making kerosene emulsion.

b. Mixing the kerosene with the hot water and soap.

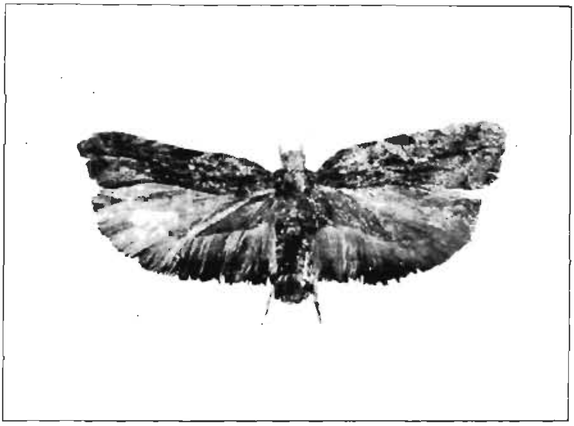
POTATO APHID CONTROL.

a. Infested peach cut open to show larva. Somewhat enlarged. (After Quaintance and Wood, Bureau of Entomology, U. S. *Department of Agriculture.)*

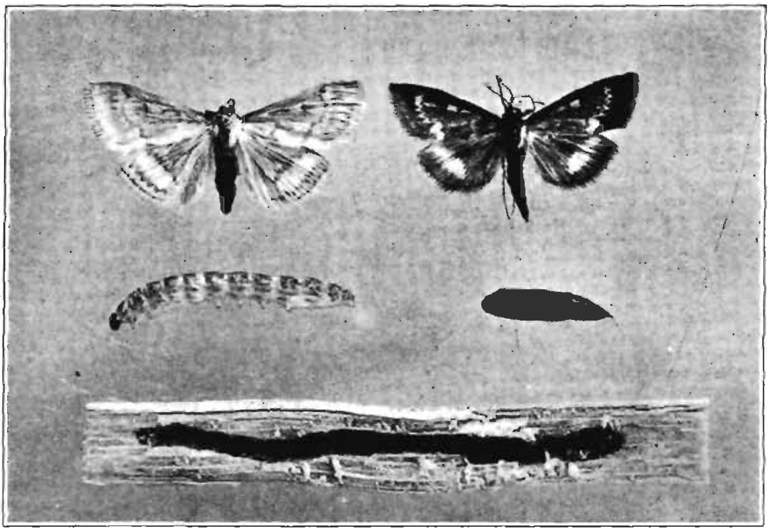
b. Peach twigs which have been injured by the larvae. Natural size.

ORIENTAL PEACH MOTH.

PLATE XXX.

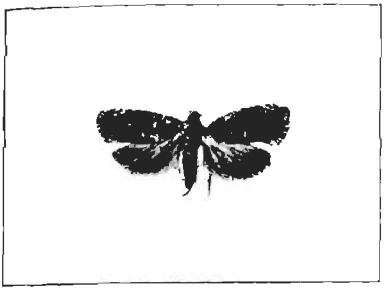


a. Peach twig borer *Anarsia lineatella.* Adult, much enlarged.



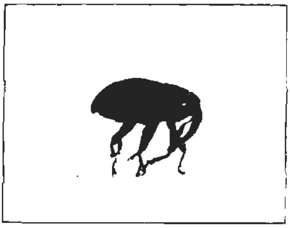
b. The European corn borer, showing female, male, larva, pupa and burrow in cornstalk. Slightly enlarged.

PEACH TWIG BORER AND EUROPEAN CORN BORER.

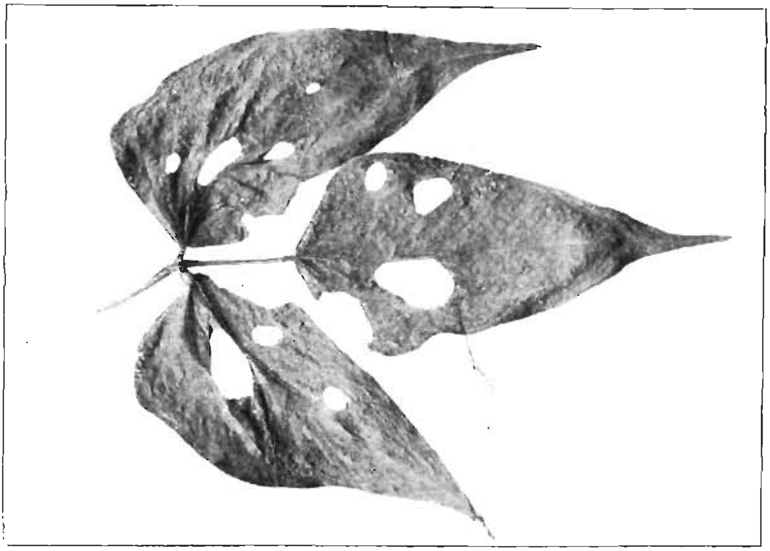


a. *Olethreutes hebesana* twice enlarged.

c. Bean leaf beetle, five times enlarged.



b. Orchid weevil, eight times enlarged.

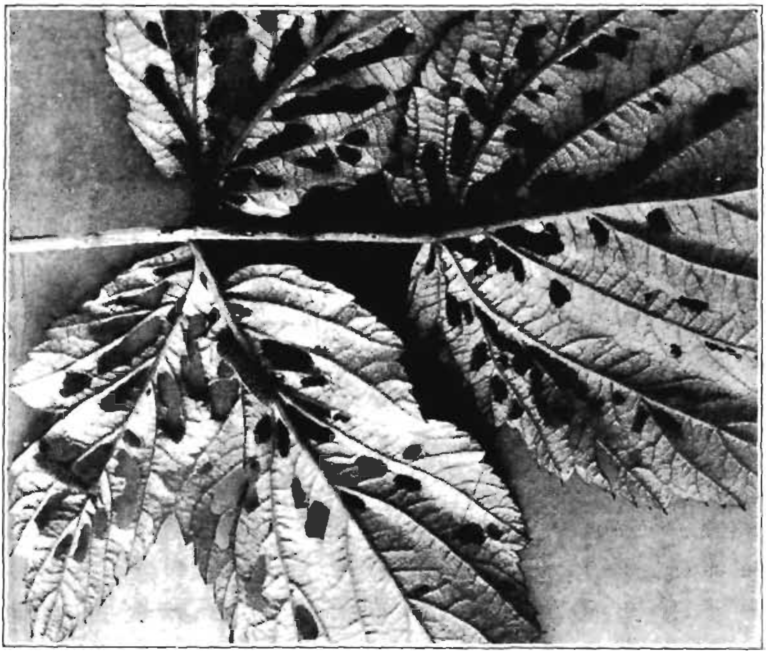


d. Bean leaf injured by bean leaf beetle. Reduced about one-half.

BEAN LEAF BEETLE, ORCHID WEEVIL, ETC.

PLATE XXXII.

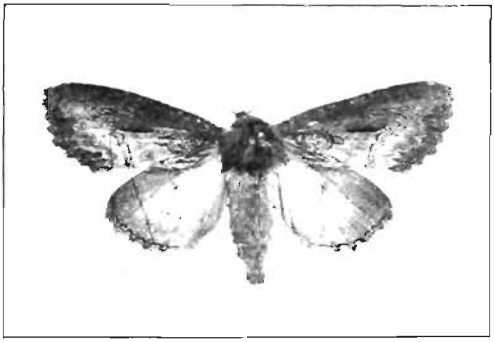
a. Larva on leaf, twice enlarged.



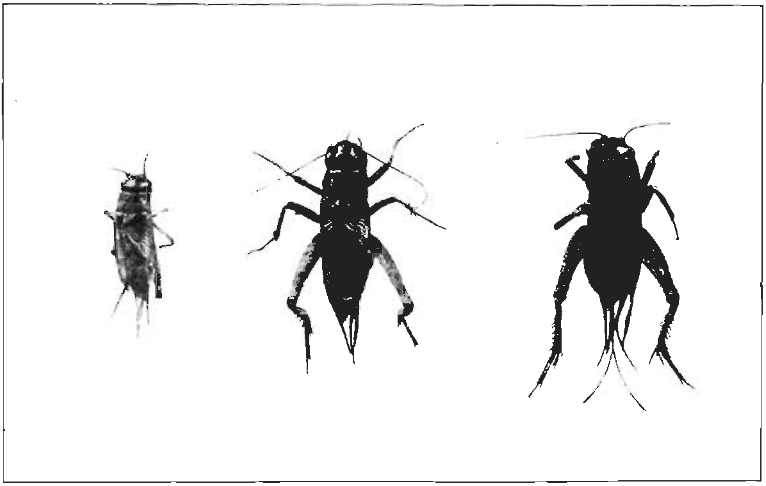
b. Leaves riddled by larvae, natural size.

RASPBERRY SAWFLY.

a. Iris borer.
Natural Size.

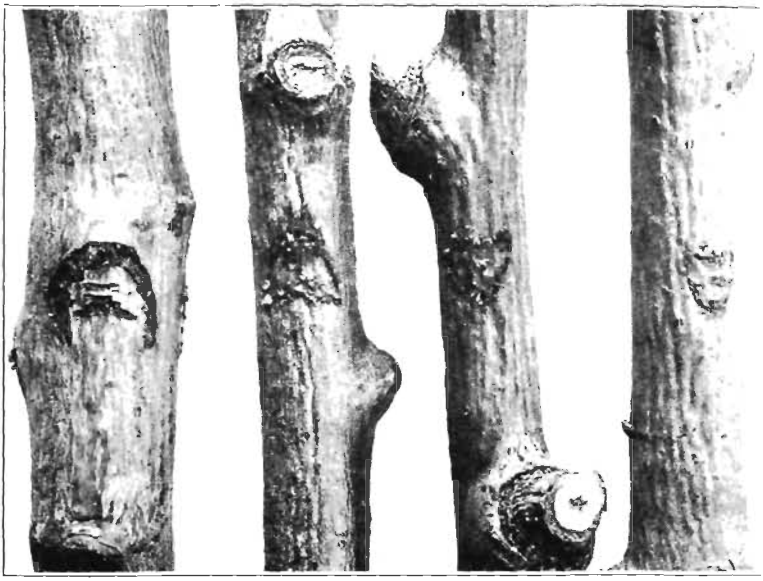


b. Adult of Iris borer. Natural size.

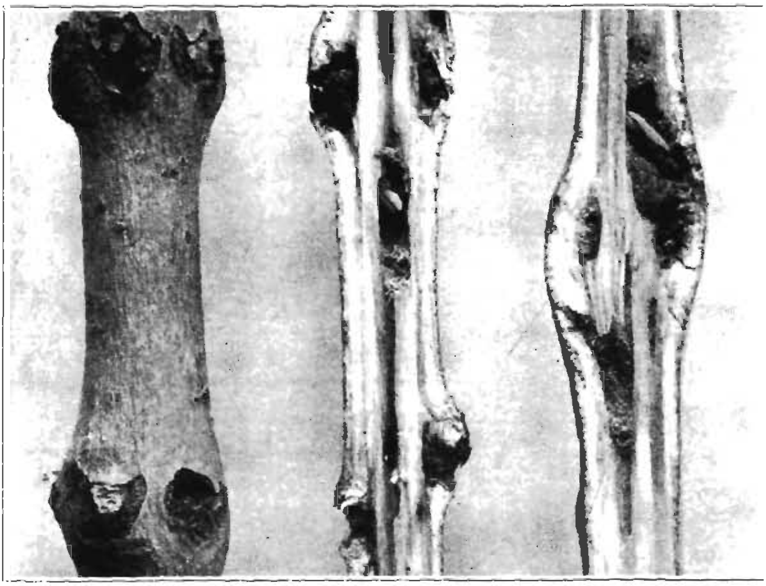


c. European house cricket. Somewhat enlarged.

IRIS BORER AND EUROPEAN HOUSE CRICKET.

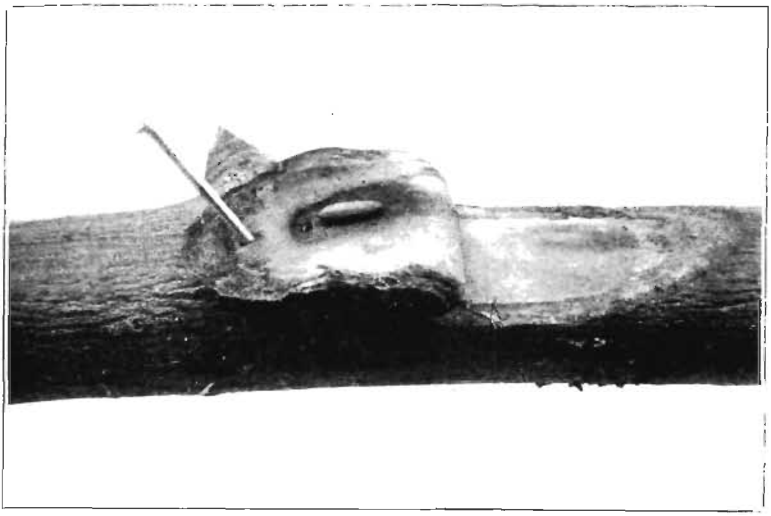


a. Poplar twigs showing triangular areas where eggs are laid. Twice enlarged.

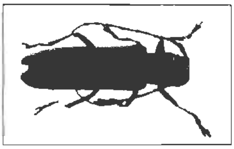


b. Poplar twigs showing tunnels and swellings. Natural size.

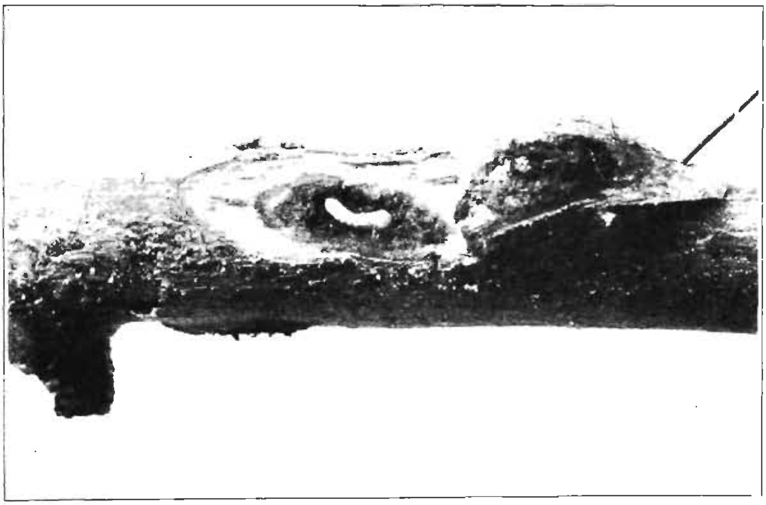
POPLAR GIRDLER.



a. Egg under bark, enlarged four times.



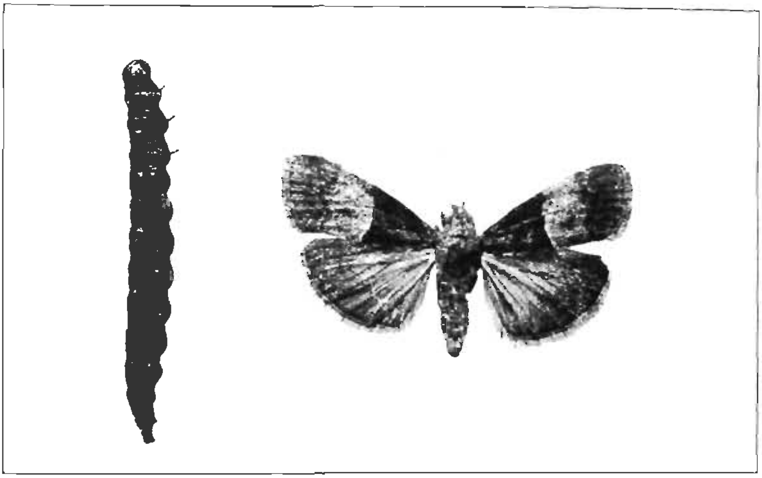
b. Adult poplar girdler. Twice enlarged.



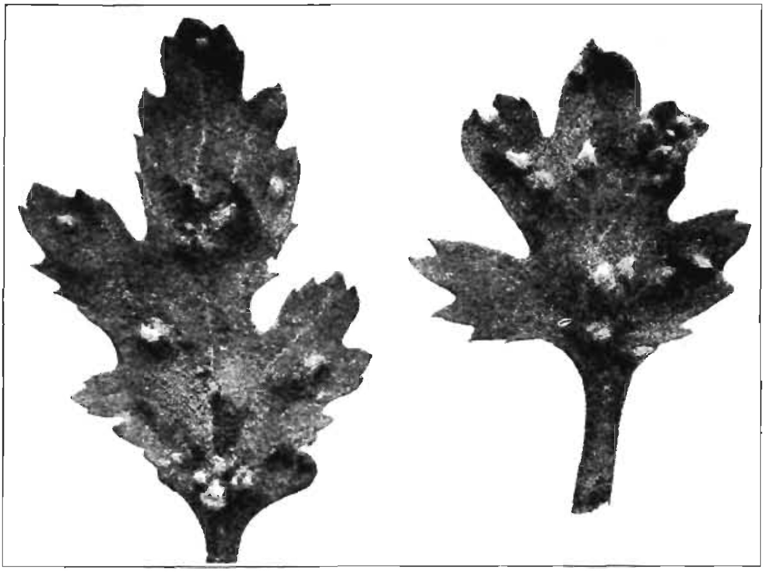
c. Young larva beginning to tunnel in twig, enlarged four times.

POPLAR GIRDLER.

PLATE XXXVI.



a. Larva and adult of *Tetralopha robustella*, a moth attacking white pine. Twice enlarged.



b. Galls on chrysanthemum leaves caused by the chrysanthemum gall midge. Twice natural size.

CHRYSANTHEMUM GALL MIDGE AND MOTH ATTACKING WHITE PINE.

Connecticut Agricultural Experiment Station

NEW HAVEN, CONN.

BULLETIN 212 MARCH, 1919

Being the Report on Commercial Feeding Stuffs 1918

By E. M. BAILEY

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The Bulletins of this Station are mailed free to citizens of Connecticut who apply for them, and to others as far as the editions permit.

The following coefficients of digestibility for some common commercial concentrates are given in Table I.

TABLE I. COEFFICIENTS OF DIGESTIBILITY OF FEEDING STUFFS.[1]

	Protein	Fiber	Carbohydrates	Fat
Cottonseed Meal	84	37	75	95
Cottonseed Feed	58	45	61	90
Linseed Meal (old process)	89	57	78	89
Linseed Meal (new process)	86	73	87	95
Wheat Bran	76	43	74	62
Wheat Feed	77	36	76	87
Wheat Middlings	77	30	78	88
Red Dog Flour	88	36	88	86
Rye Feed	80	..	88	90
Barley, ground	88	70	93	86
Barley Bran	85	20	86	87
Corn Gluten Meal	85	55	90	93
Corn Gluten Feed	85	76	88	85
Hominy Feed	66	76	90	91
Brewers' Grains	81	49	57	89
Malt Sprouts	77	87	80	85
Distillers' Grains, Corn	73	95	81	95
Distillers' Grains, Rye	59	..	67	84
Beet Pulp, dried	52	83	83	..
Peanut Cake, without shells	90	9	84	90
Soybean Meal, fat extracted	92	99	100	68
Cocoanut Cake	90	23	87	100

Nutritive Ratio. The nutritive ratio of a feed means the ratio between the digestible protein and the amount of digestible carbohydrates (nitrogen-free extract and fiber) and crude fat (ether extract) which that feed contains. One part of fat has as much energy producing capacity as 2.25 parts of carbohydrates; hence, the percentage of fat is multiplied by 2.25 before stating the proportion.

Taking as an example, cottonseed meal containing digestible nutrients of 29.8 per cent. protein, 4.5 per cent. fiber, 24.2 per cent. nitrogen-free extract and 6.2 per cent. fat, the nutritive ratio is calculated and expressed as follows:

6.2x2.25 = 14.0 energy value of fat on same basis as carbohydrate

24.2*+4.5+14.0 = 42.7 digestible carbohydrate and fat equivalent

$$\frac{42.7}{29.8} = 1.4$$

1:1.4 = the nutritive ratio of cottonseed meal.

[1] Henry and Morrison, Feeds and Feeding, p. 647, et seq.

* Conn. Agr. Exp. Sta. Bul. 206, p. 454, first line; 29.8 should read 24.2 and the nutritive ratio accordingly should be 1:1.4.

A ratio having a high proportion of protein as compared with the carbohydrate and fat combined is said to be *narrow*; when the reverse is true it is said to be *wide*.

Rations. The term ration signifies the amount of feed which should be sufficient for an animal for 24 hours. If such a ration contains the several nutrients in such proportion and amount as to properly nourish the animal without excess, it constitutes a *balanced* ration. When it contains the several nutrients in such proportion and amount that a resting animal fed thereon neither gains not loses weight, it is called a *maintenance* ration.

Compounding Rations. There is no recipe or formula for calculating rations for animals which the inexperienced can follow with assured success. Coefficients of digestibility, nutritive ratios and balanced rations are useful as guides, but should not be accepted as detailed specifications. As in any other field of endeavor, the methods and practice of those who are successful afford lessons which should not be overlooked. A ration worked out with painstaking care as to theoretical niceties may prove unsatisfactory because it lacks some practical consideration; for example, palatability. Later in this report we shall refer to the promising outlook for velvet bean and copra cake meals, since they both contain proteins of a desirable type, yet we have met with the most practical objection that animals will not eat these feeds. It must be remembered that animals, as well as human beings, acquire tastes, and it is not strange that they should refuse rations containing these new feeds alone or in too great a proportion in mixture.

The economic side of the feeding problem is important to success, and a ration not strictly balanced may yet be the most economical financially, and not necessarily unsatisfactory from a nutritive standpoint. Thus a feeder with an excess of carbohydrate feed on hand may find it to his financial advantage to overbalance his rations with carbohydrate nutrients. If the protein nutrients of the ration are not excessively low, he will reason correctly that, since carbohydrates have the function of reducing the amount of protein required (protein-sparing function) by the animal, the overbalance is justified on theoretical principles.

In compounding rations the gross supply of any group of nutrients is not, properly, of chief importance. Feeding experi-

ments have shown that economy in the use of protein, for example, depends on a proper combination of feeds. Animals will grow faster, consume less protein and less food when cereal grains are combined with milk, meat, cottonseed meal, soybean meal, etc., than when grain alone supplies protein. Thus, the best nutritive ratio for growing stock, milch cows, or laying hens, is not a fixed ratio, but one adjusted on the basis of the nature and quality of the protein supplied.

Remarks on the Inspection of 1918.

(The analyses are tabulated on pages 376 to 393.)

Cottonseed Meal. This product is recognized by the Association of Feed Control Officials and generally in the trade as a product of the cottonseed only, composed principally of the kernel with such portion of the hull as is necessary in the manufacture of oil; provided that nothing shall be recognized as cottonseed meal that does not conform to the foregoing definition and that does not contain at least 36 per cent. of protein.

There are three classes of meals,viz., Choice, Prime and Good.

Choice cottonseed meal must be finely ground, not necessarily bolted, perfectly sound and sweet in odor, yellow, free from excess of lint, and must contain at least 41 per cent. of protein.

Prime cottonseed meal must be finely ground, not necessarily bolted, of sweet odor, reasonably bright in color, yellow, not brown or reddish, free from excess of lint, and must contain at least 38.6 per cent. of protein.

Good cottonseed meal must be finely ground, not necessarily bolted, of sweet odor, reasonably bright in color, and must contain at least 36 per cent. of protein.

Only seven samples have been analyzed this year. They have averaged 36.01 per cent. of protein, and 6.46 per cent. of fat, while the average guaranty has been 36.00 per cent. of protein and 5.14 per cent. of fat, so that collectively, they have equaled or exceeded their guaranties.

11877, *Buckeye,* and **11842,** *Surety,* were deficient in protein to the extent of 2.62 per cent. and 2.81 per cent. respectively.

Only one sample, **11951,** *Goodlow,* could be classed as prime meal.

The use of any metal in affixing tags is illegal in this state. Tags were attached by means of wire to **11857,** *Gilt Edge,* **11842,** *Surety,* and **11890,** *Danish,* brands.

The selling price per ton has averaged $65.57, which is $8.02 higher than last year and $18.62 in advance of the average price two years ago.

Cottonseed Feed is a mixture of cottonseed meal and cottonseed hulls containing less than 36 per cent. of protein.

Of the two samples examined one, **11873,** *Jay* brand, was satisfactorily close to guaranty, but bore illegally attached tags. The other, **11830,** *Hall* brand, failed to meet its guaranty of protein by 4.62 per cent. and of fat by 0.55 per cent.

Linseed Meal is the ground product obtained after extraction of part of the oil from ground flaxseed, screened and cleaned of weed seeds and other foreign materials by the most improved commercial processes. "Old Process" meal is that from which the oil is removed by hydraulic pressure. In the "New Process" the oil is removed by the use of solvents.

The two samples examined exceeded their guaranties in both protein and fat. **11849** bore illegally attached tags.

Wheat Bran is the coarse outer coating of the wheat berry obtained in the usual commercial milling process from wheat that has been cleaned and scoured.

Wheat Bran with Screenings not Exceeding Mill Run is either wheat bran with the whole mill run of screenings, or wheat bran with a portion of the mill run of screenings, provided that such portion is not an inferior portion thereof.

The five samples examined have exceeded their guaranties in both protein and fat and the quality has equalled the average of other years.

11853, *Pure* brand, bore tags illegally attached.

Wheat Mixed Feed is a mixture of the products other than the flour obtained from the milling of the wheat berry.

Eight samples of this class of feeds averaged 16.42 per cent. of protein and 5.18 per cent. of fat. All exceeded their guaranties except in two cases where deficiencies in protein of less than 1 per cent. were found.

Wheat Middlings may be *Standard Middlings* (Shorts), which are the fine particles of the outer and inner bran separated from bran and white middlings or they may be *White Middlings* which are that part of the offal of wheat intermediate between shorts or standard middlings and red dog.

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The five samples examined have exceeded their guaranties in both protein and fat and the quality has equalled the average of other years.

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The six samples examined exceeded their guaranties, averaging 16.85 per cent. of protein and 5.35 per cent. of fat. The average price per ton, $50.92, is slightly lower than a year ago.

Rye Feed and *Rye Middlings* are by-products from the rye grain corresponding to those defined under similar terms for wheat by-products.[1]

Two rye feeds and two rye middlings were examined and found to meet their guaranties. The price of these products has advanced about $8.00 per ton during the year.

Barley Feed and *Barley Middlings* are products of the barley grain and correspond to those defined under similar terms for wheat and rye.[1]

Four barley products were examined. Two were above their guaranties. One, **11901**, was deficient in fat, and another, **11848**, bore no guaranty.

Corn Gluten Feed is that portion of commercial shelled corn that remains after the separation of the larger part of the starch and the germ by the process employed in the manufacture of corn starch and glucose.

Five samples of this class of feeds were analyzed. **11922** was 1.12 per cent. under guaranty in protein, but the guaranties of the other samples were satisfactorily met. The feeds averaged 23.73 per cent. of protein and 4.01 per cent. of fat. The average selling price was $62.20 per ton.

Hominy Feed (Hominy Chop, Hominy Meal) is a mixture of the bran coating, the germ and a part of the starchy portion of the corn kernel obtained in the manufacture of hominy grit for human consumption.

The seven samples examined averaged 10.61 per cent. of protein and 6.50 per cent. of fat, all satisfying their guaranties except **11937** which was 0.45 per cent. low in fat. The average selling price was $66.86 per ton which is $2.86 higher than last year.

Corn Feed Meal is the sifting obtained in the manufacture of cracked corn and table meal made from the whole grain.

The one sample examined contained 10.25 per cent. of protein and 7.23 per cent. of fat and considerably exceeded its guaranty in both respects. It sold for $68.00 per ton.

Brewers' Grains are the properly dried residue from cereals obtained in the manufacture of beer. They consist chiefly of barley,

[1] Not an A. F. C. O. definition.

but may contain whatever other cereals were used in conjunction therewith.

Three samples examined satisfied their guaranties within reasonable limits except **11867** which was 1.57 per cent. low in protein.

Tags were illegally attached in case of **11845.**

Distillers' Grains are the dried residue from cereals obtained in the manufacture of alcohol and distilled liquors. The product shall bear the designation indicating the cereal predominating.

The one sample analyzed contained 19.63 per cent. of protein and 7.21 per cent. of fat. It bore no statement of guaranty.

Dried Beet Pulp is the dried residue obtained in the manufacture of beet sugar.[1]

Seven products of this class were examined, all of which satisfied their guaranties or did so within a reasonable margin. They contained an average of 8.86 per cent. of protein and 0.91 per cent. of fat and the average selling price was $52.28 per ton.

Velvet Bean Feed. The velvet bean[2] has been grown in the South for the past 30 years. It was first grown as a forage and fertilizing crop, but quite recently its possibilities as a concentrated feeding stuff have been recognized. The development of new varieties which are adapted to varied conditions of soil and climate has extended its cultivation from Florida to states as far north as Virginia and Pennsylvania.

The unsatisfactory condition of the cotton industry has turned the attention of many cotton planters to velvet bean production. The 1917 crop was estimated at 5,000,000 acres. The average yield of beans in the pod is from one-half to one ton per acre.

The beans grow on long tangled vines and must be harvested by hand. The crushing of the beans for feed requires especially constructed mills on account of the toughness of the pods.

The bean and pod meal makes excellent feed for cattle and hogs, the best practice being to use it mixed with other feeds; apparently its exclusive use for any considerable time is undesirable.[3] Feeding experiments show that from two to two and one-half pounds of velvet beans in the food are equal to one pound of high grade cottonseed meal.

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[1] Not an A. F. C. O. definition.

[2] U. S. Dept.Agr., Farmers' Bul. 962, 1918. Miss. Agr. Exp. Sta. Bul. 179, 1917.

[3] Henry and Morrison. Feeds and Feeding, pp. 237–238.

A study[1] of the protein of one variety of velvet bean, viz., *Chinese*, has shown that it contains all the necessary amino-acids to make it completely nutritious to animals.

Two samples of velvet bean feed have been analyzed this year. They contained between 16.00 and 17.00 per cent. of protein, about 13.00 per cent. of crude fiber and 3.3 to 4.3 per cent. of crude fat. The feeds sold for $43 and $45 per ton, respectively, making the cost per pound of protein about 13.3 cents. The average cost per pound of protein in cottonseed meal, as shown by the figures obtained this year, is 9.1 cents.

Peanut Oil Meal is the ground residue obtained in the preparation of peanut oil.[2] Like the velvet bean it is grown as a forage and soil improvement crop, but the increasing demand for peanut oil for human consumption has brought the oil cake into prominence as a concentrated stock feed. It is highly nutritious and being rich in protein and relatively so in fat it can be used to advantage to balance rations containing corn and other grains rich in starch.

The one sample examined contained 25.25 per cent. of protein and 12.55 per cent. of fat. It was 4.75 per cent. below guaranty in protein but exceeded its guaranty of fat by 5.55 per cent. It sold for $58.00 per ton, making the cost per pound of protein 11.5 cents.

Copra Cake Meal, Cocoanut Meal, Cocoanut Oil Meal is the ground residue obtained in the preparation of Cocoanut Oil.[2] The copra-crushing industry is becoming of rapidly increasing importance in the United States, due to the demand for cocoanut oil in the manufacture of nut margarines and cooking fats. Globulin, the chief protein of the cocoanut, has been shown[1] to be of the type called "complete" and feeding experiments indicate that it is adequate for normal growth. As a dairy feed it is said to produce butter of considerable firmness, which recommends it as a summer ration.[3] Its tendency to become rancid affects both its keeping qualities and its palatability.

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[3] Henry and Morrison. Feeds and Feeding, p. 157.

The one sample contained 19.44 per cent. of protein and 11.01 per cent. of fat. It was 1.56 per cent. below guaranty in protein but exceeded the guaranty of fat by 5.01 per cent. The selling price was $55.00 per ton, making the cost per pound of protein 14.1 cents.

Proprietary Mixed Feeds. To this class belong a great number of so-called "balanced" feed mixtures. Some of these represent the result of careful compounding on the basis of the best information regarding feeding values, and contain high grade ingredients. Others contain considerable amounts of such low grade materials as oat hulls, screenings, corn-cob and other by-products. These give bulk to the feed but have little to recommend them from a nutritive standpoint. Owing to the high cost of such rations, the feeder should use only standard brands or those of demonstrated worth. Analyses will detect deficiencies of gross nutrient materials, but only actual feeding tests will demonstrate the quality of the nutrients.

Many brands bear on the tag, in addition to the chemical guaranty, a statement of the ingredients which enter into their composition. Information of this kind, not required by law in this state, is given by the manufacturers of the following feeds:

Barford's Ready Ration for Horses. Hominy feed, oat feed, brewers' grain, cocoanut oil meal, linseed oil meal, alfalfa meal, sugar cane molasses, salt.

Barford's Ready Ration for Growing Pigs. Hominy feed, peanut meal, old process linseed oil meal, gluten feed, cocoanut oil meal, alfalfa meal, sugar cane molasses, 1½ per cent. charcoal, 1 per cent. salt.

Bufceco Chop Feed. Ground corn, oats and barley, hominy feed, oat shorts and oat hulls.

Bufceco Creamery Feed. Ground corn, wheat bran and middlings, hominy feed, corn gluten feed, cottonseed meal, oat shorts, oat middlings, oat hulls, ½ of 1 per cent. salt.

Bufceco Horse Feed. Ground oats, corn and barley, wheat middlings, hominy feed, oat shorts, oat middlings, oat hulls, linseed meal, corn gluten feed.

Bufceco Steam Cooked Feed. Ground corn and oats, hominy feed, oat shorts, oat middlings, oat hulls and ½ of 1 per cent. salt.

Bufceco Stock Feed. Ground corn, oats and barley, wheat middlings, corn gluten feed, hominy feed, oat shorts, oat middlings and oat hulls, ½ of 1 per cent. salt.

Crosby's 1918 Dairy Ration. Distillery dried grains, cotton seed meal, peanut meal, brewers' dried grains, hominy feed and oat feed (oat hulls, oat shorts, oat middlings).

Emerald Horse Feed. Cracked corn, oats, barley, alfalfa meal and molasses.

Larrowe's Big Six. Linseed oil meal, cotton seed meal, corn gluten feed, hominy feed, corn feed meal, rye middlings, wheat bran, wheat middlings and ¾ of 1 per cent. salt. Bran and middlings may contain "ground screenings not exceeding mill run."

Larro-feed. Cotton seed meal, corn gluten feed, corn feed meal, old process linseed oil meal, dried beet pulp, standard wheat bran, standard wheat middlings and ¾ of 1 per cent. salt. Wheat bran and wheat middlings may contain "ground screenings not exceeding mill run."

Pennant Stock Feed. Fine white hominy and oat by-products, ½ of 1 per cent. salt.

Purina Cow Chow Feed. Cotton seed meal, linseed oil meal (old process), gluten feed from corn, hominy feed, ground alfalfa, molasses and one per cent. salt.

Purina Pig Chow. Hominy feed, corn feed meal, molasses, alfalfa, digester tankage, charcoal and 1 per cent. salt.

Union Grains. Fourex Corn Distillers' Dried Grains, choice cottonseed meal, old process linseed meal, white wheat middlings, winter wheat bran, hominy meal, corn germ meal, corn gluten feed, brewers' dried grains, barley malt sprouts, ½ of 1 per cent. fine table salt.

Fifty-four feeds of this class have been examined this year. Eleven of these have failed to meet their guaranties in protein, fat, or both, by one per cent. or more of protein and one quarter of one per cent. or more of fat.

Guaranties of fiber are not required by law in this state, but, if made, they should be correct. In addition to the above deficiencies two other brands contained fiber exceeding the guaranteed maximum by one per cent. or more.

The deficient brands are as follows:

TABLE II. PROPRIETARY BRANDS VARYING FROM GUARANTY.

No.	Brand	Protein Deficiency %	Fat Deficiency %	Fiber Excess %
11887	Red Horn Calf Meal................	2.50	0.81	....
11924	Purina Calf Chow.................	2.50	....	....
11941	Alfalfa Strong Horse Feed..........	....	1.07	....
11917	Bufceco Steam Cooked Horse Feed..	....	0.28	....
11900	Barford's Ready Ration for Horses..	....	....	1.64
11945	Emerald Horse Feed..............	....	0.28	4.87
11919	Purina Pig Chow..................	....	....	3.21
11921	Purina Cow Chow.................	....	0.35	....
11908	Pennant Stock Feed...............	1.25	1.77	....
11909	Crosby's 1918 Dairy Ration.........	4.62	....	3.48
11915	Economic Special Dairy Feed.......	1.87	....	....
11889	Red Horn Dairy Feed..............	1.06	....	....
11911	Haskell's Stock Feed...............	....	2.40	....

The five calf meals examined have sold uniformly for $100.00 per ton. *Red Horn* contained the least protein; viz., 15.50 per cent., and the purchaser paid 32.3 cents per pound for protein in this ration. *Purina* contained the highest amount of protein; viz., 30.50 per cent., and the cost of protein in this feed was 16.4 cents.

Among horse feeds the lowest protein content, 8.50 per cent., was found in *Bufceco Steam Cooked Feed* which sold for $65.00 per ton, making the cost of protein per pound 38.2 cents. *Green Velvet*, highest in protein of those of which we have knowledge of the selling price, and highest but one of all, sold for $57.50 per ton, making the cost of protein per pound 15.0 cents.

Among stock and dairy feeds the lowest protein content, 8.31 per cent., was found in *Haskell's* which sold for $61.00 per ton. The highest, 27.31 per cent., was in *Unicorn*, which sold for $70.00. The cost of protein per pound was 36.1 and 12.8 cents, respectively.

These comparisons show that in the low-protein rations the purchaser has paid the highest price per unit of protein, and that the cheapest way to buy protein is not necessarily in the feed with the lowest selling price per ton. However, it must be recognized that comparisons of this kind do not furnish a means of final judgment as to the merits of the several feeds, since they are based upon the assumption that all proteins are of

equal feeding value, an assumption which recent experiments have shown is not at all justified.

Poultry Feeds. Information regarding the ingredients used in compounding some of the mixtures of this group of feeds has been given by the manufacturers of the following brands:

Bufceco Poultry Mash. Ground corn, wheat bran, middlings, hominy feed, corn gluten feed, oat middlings and rolled oats.

H-O Co.'s Poultry Feed. Ground corn, corn gluten feed, wheat middlings, wheat bran, hominy feed, rolled oats, ground peas, ground grain screenings, molasses, linseed oil meal.

Lay or Bust. Corn, wheat, oats, barley, Kafir corn, buckwheat, alfalfa, fish, meat, bone, wheat bran with mill run screenings, wheat middlings, calcium carbonate and salt.

M and S Dry Mash. Bran, middlings, gluten, corn meal, beef scraps, alfalfa meal, hominy and salt.

Tom Boy Poultry Mash. Ground meat, wheat, oat meal, wheat middlings, milo maize, buckwheat, corn meal, barley, oat middlings, millet, gluten feed, Kafir corn, alfalfa meal, hominy feed, wheat bran, oat germ meal, rock phosphate, salt, calcium carbonate and charcoal.

Of these feeds *Bufceco* contained the lowest amount of protein; viz., 14.00 per cent, and sold for $75.00 per ton. Protein in this ration cost 26.8 cents per pound. *Chic-Chuck* contained the highest amount; viz., 52.13 per cent, and sold for $88.00, making the cost per pound of protein in this feed 8.4 cents.

11826, *Bufceco,* **11912,** *Mystic,* and **11927** *Platt's,* failed to meet their guaranties by 1.17, 4.06 and 1.06 per cent. respectively.

11833, *Chic Chuck* was deficient in fat by 0.67 per cent.

STOCK AND POULTRY FEEDS CONTAINING MOLASSES.

Six of these feeds contained molasses, according to the declaration of their ingredients. These were accordingly re-examined for crude fat by first washing out saccharine materials with water, drying and finally extracting for sixteen hours with anhydrous ether.

The results are given in the following tabulation:

TABLE III—FAT IN MOLASSES FEEDS.

No.	Brand	Official Method %	Modified Method %	Guaranty %
11900	Barford's Ready Ration for Horses....	4.09	3.54	3.00
11899	Barford's Ready Rations for Pigs.....	6.24	5.10	5.00
11945	Emerald Horse Feed................	1.72	1.49	2.00
11921	Purina Cow Chow Feed.............	4.45	3.97	4.80
11919	Purina Pig Chow Feed..............	3.56	3.38	3.20
11874	H-O Co's Poultry Feed..............	5.89	4.95	4.50

In past years it has been found in some cases that feeds containing molasses did not receive credit for the guaranteed amount of fat, when the regular method of extraction was followed. The modified method has not, however, given uniformly higher results and the figures this year are in all cases lower.

MISCELLANEOUS SAMPLES.

Partial or complete analyses of the following miscellaneous materials have been made:

SAMPLES SUBMITTED BY THE DAIRY AND FOOD COMMISSIONER.

The numbers of the following samples are of the Dairy and Food Commissioner's series.

Cottonseed Meal. **13750** contained 36.94 per cent. of protein. **12311** contained 35.44 per cent. of protein.

Stock Feeds. **13935, 13936** and **13937** were suspected of containing ground rock.

None of the feeds contained excessive amounts of total ash or of acid-insoluble ash and macroscopic examination revealed nothing suspicous.

SAMPLES SUBMITTED BY INDIVIDUALS.

Barley Feed. **11440,** Pillsbury's Barley Mill Feed, sent by B. Willett, Uncasville.

11112, composed of barley hulls, middlings and screenings, sent by C. A. Stone, Waterbury. Analyses of these samples were made as follows:

	11440 Found %	11440 Guaranty %	11112 Found %	11112 Guaranty %
Water	9.54	.....	.....	....
Ash	5.35	.....	.....	....
Protein	11.88	8.00	10.63	6.00
Nitrogen-free extract	69.84	50.00	.....	....
Fat	3.38	2.00	3.19	1.00
Price per ton	$50.00	.....	.....	....

Bran, **10672**, Washburn-Crosby Co., **10673**, manufacturer unknown, both sent by Walter C. Cook, Litchfield, were found to contain 15.31 and 15.81 per cent. of protein, respectively, and were of average quality.

Corn. **10674** was corn that had heated in the car and moulded somewhat. It was removed, kiln-dried and used as feed for pigs. The sample was submitted by A. N. Farnham, Hamden, and found to contain 10.50 per cent. of moisture, 1.38 per cent. of ash, 9.38 per cent. of protein, 2.16 per cent of fiber, 73.38 per cent. of carbohydrates and 3.20 per cent. of fat.

11221, 11222 and **11223** were varieties of corn, analyses of which were made for the Department of Plant Breeding.

	11221 (Sweet) %	11222 (Pseudo-starchy) %	11223 (Starchy) %
Moisture	10.60	11.09	11.41
Ash	2.07	1.65	1.46
Protein	14.51	12.69	11.60
Fiber	1.89	1.73	1.31
Fat	7.52	5.94	4.07
Soluble carbohydrates, calculated as dextrose	26.15	7.19	4.45
Insoluble carbohydrates, starch	29.00	51.50	58.73
Undetermined nitrogen-free extract	8.26	8.21	6.97

Cottonseed Meal. **10582, 10631, 11255, 11674,** manufacturer or jobber not known; **10849**, Puritan brand, J. E. Soper Co., Boston; **10853**, Surety brand, **10888, 12133,** The American Cotton Oil Co., New York; **11734, 11774, 11816, 11817, 12103,** Humphreys Godwin Co., Memphis, Tenn, all sent by the Coles Co., Middletown.

10583, H. L. Buss & Co., Boston, sent by Geo. S. Phelps, Thompsonville.

10685, T. L. Smith, Birminghan, Ala., sent by R. N. Dean, Sharon.

11016 and **11017**, Dixie Brand, Chas. M. Cox Co., Boston, sent by Samuel J. Orr, West Suffield.

11045, H. L. Buss & Co., Boston, sampled by Station Agent from stock of Laden Bros., Wallingford.

11256 and **11257**, sent by the C. W. Campbell Co., Westerly, R. I.

11271, Farmers Cotton Oil and Fertilizer Co., Huntsville, Ala., sent by B. W. Ellis, County Agent, Putnam.

11995, sent by E. A. Brown, County Agent, Hartford.

12144 and **12145**, sent by A. W. Manchester, County Agent, Litchfield.

11442, sent by R. M. Fenn, Middlebury.

Table IV. Analyses of Cottonseed Meals.

No.	Protein Found %	Protein Guaranteed %	Price per ton $
10582	37.06	.....	.....
10631	37.63	.....	.....
11255	32.38	.....	.....
11674	34.25	.....	.....
10849	36.37	36.00	60.00
10853	35.00	36.00	60.00
10888	34.06	.....	60.00
12133	37.00	36.00	63.02
11734	29.50	36.00	56.85
11774	34.81	36.00	56.85
11816	35.19	36.00	62.50
11817	35.31	36.00	62.50
12103*	32.31	36.00	56.85
10583	34.75	36.00	57.00
10685	31.25	36.00	.....
11016	41.06	41.00	57.00
11017	40.88	41.00	57.00
11045	37.00	.....	.....
11256	33.44	.....	.....
11257	35.63	.....	.....
11271	36.81	36.00	.....
11995	43.31	41.00	.....
12144	38.31	43.00	.....
12145	43.00	41.00	.....
11442	31.88	.....	.....

*New sample from same lot as 11734.

Ensilage. **11361**, sent by C. M. Jarvis, Berlin, was found to contain 63.75 per cent. of water, 2.68 per cent. of ash, 3.43 per cent. of protein, 10.71 per cent. of fiber, 18.46 per cent. of carbohydrates, and 0.97 per cent. of fat.

Gluten Feed. **11271**, sent by B. W. Ellis, County Agent, Putnam, guaranteed to contain 23.00 per cent of protein, was found to contain 18.69 per cent.

12143, sent by B. W. Ellis, County Agent, Putnam, contained 23.56 per cent. of protein.

Hominy Feed. **10983**, sent by Chas. M. Cox Co., Boston, for an opinion as to its genuineness. The sample was of course texture and contained 8.94 per cent. of protein and 7.42 per cent. of fiber.

The average of 304 analyses of hominy meal was found to be 10.7 per cent. of protein and 4.6 per cent. of fiber; also the average of 19 analyses of hominy and corn cob was 8.9 per cent. of protein and 9.4 per cent. of fiber.[1] This sample is low in protein and high in fiber for hominy meal or feed and appears to contain an excess of material of high fiber content like corn cob.

10842, sent by A. D. MacDowell, Washington, contained 10.31 per cent. of protein.

Poultry and Hog Feeds. **11165**, Mash, sent by the Frank S. Platt Co., New Haven, contained 20.19 per cent of protein.

12148, Beef Scrap, said to have come from South America and advertised to contain 48 per cent. of protein, sent by T. F. Dexter, Kent, contained 26.50 per cent. protein.

12162 and **12163**, Digester Tankage, manufactured by Robt. A. Reichard, Allentown, Pa., sent by Curtis Hull, Wallingford. The samples were guaranteed to contain 40 and 60 per cent. of protein, respectively; **12162** contained 50.38 and **12163** contained 64.81 per cent. of protein.

11259, Bean Mash, sent by A. B. Hall, Wallingford; **11275** and **11343**, Pig Feeds, sent by Meech & Stoddard, Inc., Middletown. **11275** is stated to be composed of gluten feed, hominy feed, cocoanut oil meal, brewers' grains, linseed meal, molasses, charcoal and salt. **11343** has the same ingredients except that peanut meal is substituted for brewers' grains.

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[1] Rpt. Conn. Agr. Expt. Sta., Commercial Feeding stuffs, 1913, p.344

	11259 %	11275 %	11343 %
Water	11.70	10.93	11.30
Ash	4.37	5.91	6.08
Protein	19.38	13.88	19.38
Fiber	11.15	10.90	9.51
Nitrogen-free extract	51.93	54.26	48.15
Fat	1.47	4.12	5.58

Proprietary Mixed Feeds. **11268,** Copra Cake Meal, **11269,** Barford's Ready Ration for Horses, and **11728,** were all sent by Meech and Stoddard, Inc., Middletown. **11269** is stated to contain hominy feed, oat feed, brewers' grains, cocoanut oil meal, linseed meal, alfalfa meal, sugar cane molasses and salt. It is guaranteed to contain 10 per cent. of crude protein and 3 per cent. of crude fat. **11728** is stated to contain ground barley, peanut meal, hominy feed, gluten feed, cocoanut oil and meal, linseed oil meal, corn meal, charcoal and salt.

	11268 %	*11269* %	*11728* %
Water	11.32	12.53	9.84
Ash	5.72	6.02	4.50
Protein	19.56	11.00	17.88
Fiber	9.97	14.55	8.64
Nitrogen-free extract	44.40	52.36	53.32
Fat	9.03	3.54	5.82

11439, *Marathon Stock Feed,* manufactured by Fred L. Cressey, Boston, was sent by B. Willett, Uncasville. The feed is said to be a mixture of hominy, oat feed, velvet bean meal and salt, and is guaranteed to contain 9 per cent. of protein and 4 per cent. of fat.

It contained 8.82 per cent. of moisture, 4.82 per cent. of ash, 10.63 per cent. of protein, 72.07 per cent. of carbohydrates and 3.66 per cent. of fat.

Miscellaneous Feeds. **12192,** Wheat Flour, low grade, and **12193,** a mixture containing 5 per cent. of wheat flour, sent by H. W. Hovey, New Haven, contained 15.19 and 16.06 per cent. of protein, respectively.

10604, Meal made from cull Brazilian Beans, sent by A. W. Manchester, Litchfield, contained 23.31 per cent. of protein.

10611, 10612, 10613 and **10614** were feeds sent by L. R. Michels, Southport. The analyses are as follows:

	10611	10612	10613	10614
	%	%	%	%
Water	6.87	6.69	6.91	6.53
Ash	11.70	7.40	7.40	7.06
Protein	15.31	13.50	14.13	11.63
Fiber	19.23	19.38	19.39	21.25
Nitrogen-free extract	44.97	51.09	50.23	51.94
Fat	1.92	1.94	1.94	1.59

10626, Brewery Grains, **10627,** Burnt Corn Meal, **10628,** Malt Sprouts, and **10629,** Linseed Screenings, all sent by Lawrence A. Bevan, County Agent, Danbury, contained, in the order named, 7.50, 9.25, 22.13 and 10.44 per cent. of protein.

Low prices had been obtained on all the above feeds. **10626** appeared to be sweepings and contained only about one-third as much protein as the average of brewers' grains.

Feeds or other materials suspected of containing injurious substances. Four complaints have come to us regarding feeds which animals would not eat, or which were thought to have caused illness or death of animals fed with them. Unless arsenic or other poisonous metals, or certain alkaloidal poisons such as strychnine, can be detected in such cases, a satisfactory explanation to the person making the complaint seldom can be given.

A mixture containing feeds that are new or to which animals are unaccustomed will be rejected until a relish for them has been gradually acquired. This has seemed to be the most reasonable explanation in some cases.

In the case of chicks, suffocation from over-eating has sometimes appeared to have been the source of trouble; in other instances where large numbers of chicks have died the circumstances have pointed to a probable epidemic disease rather than to the particular feed being given at the time.

Weed seeds, as, for example, certain varieties of mustard, produce poisonous effects in cattle, and more particularly in hogs, but no cases have come to our attention in which this could be offered as a probable cause.

11973, Stock Salt, thought to have caused injury to horses, was sent to us at the suggestion of the Deputy Commissioner of Domestic Animals. The sample was free from arsenic and toxic heavy metals, and contained 98 per cent. of pure sodium chloride, showing it to be a high grade of salt.

CONDIMENTAL FOODS AND REMEDIES.

To this class belong preparations variously called stock foods, stock remedies, tonics, regulators or conditioners. The base of such mixtures is generally some common feeding stuff reinforced with cathartics or appetizers or both. The cathartics may be sodium sulphate (Glauber's salt), magnesium sulphate (Epsom salt), or a vegetable laxative. Bitter and other vegetable principles and mineral substances serve as appetizers and may include gentian, fenugreek, quassia, anise, worm seed, pepper, ginger, iron oxide, iron sulphate, sulphur, common salt and saltpeter. Poultry foods may contain also Venetian red, bone, grit, carbonates and mustard.

These remedies may serve to correct mild disorders and produce indirect benefit in other ways, but their high cost will overbalance their actual worth in continued practice. Henry and Morrison[1] suggest three formulas, the ingredients for which are readily obtained, which may be home mixed at considerably reduced cost and which will supply medicament of as great value as the majority of the commercial mixtures. Their suggestions are worthy of the notice of any large feeders who have occasion to use considerable amounts of remedies of this sort. As a rule the appetites of animals properly fed and kept require but little attention.

Thirteen preparations of this class, and one remedy sent by Karl B. Musser, Storrs, have been examined.

The results of the inspection appear on pages 394 and 395.

[1] Feeds and Feeding, p. 192.

TABLE V. ANALYSES OF COMMERCIAL FEEDS,

Station No.	Brand.	Retail Dealer.
	OIL SEED PRODUCTS. *Cottonseed Meal.*	
11951	Goodlow. M. F. Baringer, Philadelphia, Pa....	*Stamford:* W. L. Cra
		Guaranty..........
11877	Buckeye. Buckeye Cotton Oil Co., Cincinnati, O.	*Unionville:* F. D. La Son.............
		Guaranty..........
11857†	Gilt Edge. Empire Cotton Oil Co., Atlanta, Ga.	*Middletown:* Meech dard, Inc........
		Guaranty..........
11890†	Danish. Humphreys, Godwin Co., Memphis, Tenn..................................	*Rockville:* Edward W
		Guaranty..........
11864	Danish. Humphreys, Godwin Co., Memphis, Tenn..................................	*New Britain:* C. W Co..............
		Guaranty..........
11930	Puritan. J. E. Soper Co., Boston, Mass.......	*Winsted:* E. Manch Sons............
		Guaranty..........
11842†	Surety. Union Seed & Fert'z'r Co., Memphis, Tenn..................................	*Guilford:* Morse & La
		Guaranty..........
		Average guaranty..
		Average of analyses.
		Average digestible...
	Cottonseed Feed.	
11873†	Jay. F. W. Brode & Co., Memphis, Tenn.....	*Bristol:* Goodsell Br
		Guaranty..........
11830	Hall. W. D. Hall Co., Atlanta, Ga...........	*Wallingford:* A. E. I
		Guaranty..........
		Average guaranty..
		Average of analyses.
		Average digestible..
	Linseed Meal, Old Process.	
11866	Oil Meal. Spencer Kellogg Co., Buffalo, N. Y...	*Plantsville:* C. A. Cc
		Guaranty..........
11849†	Oil Meal. American Linseed Co., N. Y........	*West Cheshire:* G. W.
		Guaranty..........
		Average guaranty..
		Average of analyses.
		Average digestible..
	WHEAT PRODUCTS. *Wheat Bran.*	
11844	Bernet, Craft & Kauffman Milling Co., St. Louis, Mo................................	*Guilford:* Morse & I
		Guaranty..........
11883	Choice. Niagara Falls Milling Co., Niagara Falls, N. Y.............................	*Thompsonville:* G Phelps & Co.....
		Guaranty..........

† Wired tags.

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n	Pounds per Hundred.						Price per ton.
	Water.	Ash.	*Protein* (N. x 6.25)	*Fiber.*	Nitrogen-free Extract. (Starch, gum, etc.)	Ether Extract. (Crude Fat)	
l	7.73	5.45	38.94	12.36	28.32	7.20	$70.00
.	....	....	36.00	....	....	5.00	....
7	8.30	5.50	33.38	14.74	32.94	5.14	60.00
.	....	....	36.00	14.00	30.00	5.00	....
7	8.68	5.80	36.44	12.21	30.43	6.44	66.00
.	....	....	36.00	14.00	30.00	5.50	....
)	8.17	5.65	36.00	12.82	31.00	6.36	66.00
.	....	....	36.00	15.00	25.00	5.00	....
l	7.43	5.14	37.38	11.72	30.12	8.21	65.00
.	....	....	36.00	15.00	25.00	5.00	....
)	8.88	5.35	36.75	13.04	48.98	6.00	66.00
.	....	....	36.00	15.00	30.00	5.00	....
2	7.89	5.40	33.19	14.67	33.01	5.84	66.00
.	....	....	36.00	14.00	27.00	5.50	....
.	....	....	36.00	....	....	5.14	....
.	8.15	5.47	36.01	13.08	33.54	6.46	65.57
.	....	....	30.2	4.8	25.2	6.1	....
3	8.01	6.38	35.38	12.55	31.93	5.75	67.00
.	....	....	36.00	14.00	30.00	5.00	....
)	8.14	5.15	31.38	15.45	34.93	4.95	64.00
.	....	....	36.00	14.00	27.00	5.50	....
.	....	....	36.00	....	....	5.25	....
.	8.08	5.77	33.38	14.00	33.43	5.35	65.50
.	....	....	19.4	6.3	20.4	4.8	....
3	8.42	5.26	35.69	7.23	36.47	6.93	65.00
.	....	....	33.00	....	....	5.00	....
9	7.41	5.53	35.81	7.41	37.95	5.89	65.00
.	....	....	34.00	8.00	....	5.00	....
.	....	....	33.50	....	....	5.00	....
.	7.92	5.40	35.75	7.32	37.21	6.41	65.00
.	....	....	31.8	4.2	29.0	5.7	....
4	8.60	6.70	16.25	9.75	54.30	4.40	44.00
.	....	....	14.00	9.50	55.20	4.00	....
3	8.33	6.20	15.63	10.07	54.18	5.59	50.00
.	....	....	12.00	....	....	3.00	....

TABLE V.—ANALYSES OF COMMERCIAL FEEDS,

Station No	Brand.	Retail Dealer.
	WHEAT PRODUCTS—*Continued.* *Wheat Bran—Concluded.*	
11822	Angelus. Thompson Milling Co., Lockport, N.Y.	*Ansonia:* Ansonia Flour & Grain Co.
		Guaranty
11880*	Washburn-Crosby Co., Minneapolis, Minn.	*Unionville:* F. D. Lawton & Son
		Guaranty
11853†	Pure. Wells-Abbott Nieman Co., Schuyler, Neb.	*West Cheshire:* G. W. Thorpe
		Guaranty
		Average guaranty
		Average of analyses
		Average digestible
	Wheat Feed (Mixed Feed).	
11895	Boston. Duluth Superior Mill. Co., Duluth, Minn.	*Manchester:* Little & McKinney
		Guaranty
11882*	Kehlor's. Kehlor Flour Mills Co., St. Louis, Mo.	*Thompsonville:* Geo. S. Phelps & Co.
		Guaranty
11910	Occident. Russell Miller Milling Co., Minneapolis, Minn.	*Yantic:* A. R. Manning
		Guaranty
11925*	Omar. Omaha Flour Mills Co., Omaha, Neb.	*New Haven:* Crittenden-Benham Co.
		Guaranty
11893	Stott's Honest. David Stott Flour Mills, Detroit, Mich.	*Rockville:* Edward White
		Guaranty
11914	T. & C. Thornton & Chester Milling Co., Buffalo, N. Y.	*Norwich:* Chas. Slosberg & Son
		Guaranty
11885‡	Wagoner-Gates Milling Co., Independence, Ind.	*Hazardville:* A. D. Bridges' Sons
		Guaranty
11939	Kent. The Williams Bros. Co., Kent, O.	*Thomaston:* L. E. Blackman
		Guaranty
		Average guaranty
		Average of analyses
		Average digestible
	Wheat Middlings.	
11875*	Bay State. Bay State Milling Co., Winona, Minn.	*Bristol:* Eaton Bros.
		Guaranty
11879	Faylor's. Northwestern Elevator & Mill Co., Toledo, O.	*Unionville:* F. D. Lawton & Son
		Guaranty
11953	Hecker-Jones-Jewell Milling Co., New York	*Stamford:* W. L. Crabb
		Guaranty
11918*	Omar. Omaha Flour Mills, Omaha, Neb.	*New London:* P. Swartz Co.
		Guaranty

* With screenings. † Wired tags. ‡ Soft wheat with mill run bran.

INSPECTION OF 1918—*Continued.*

;ation No.	Price per Hundred.						Price per ton.
	Water.	Ash.	Protein (N. x 6.25)	Fiber.	Nitrogen-free Extract. (Starch, gum, etc.)	Ether Extract. (Crude Fat)	
822	9.72	6.96	16.06	10.13	52.23	4.90	$46.00
...	....	....	**13.00**	**8.00**	**55.00**	**4.00**	....
880	9.87	6.16	14.69	10.49	53.62	5.17	47.00
...	....	....	**13.00**	....	....	**4.00**	....
853	9.88	7.40	16.63	10.00	51.62	4.47	43.00
...	....	....	**14.00**	**10.00**	....	**3.00**	....
...	....	....	**13.20**	....	....	**3.60**	....
...	**9.28**	**6.68**	**15.85**	**10.09**	**53.19**	**4.91**	**46.00**
...	....	....	**12.0**	**4.3**	**39.4**	**3.0**	....
895	10.18	4.80	15.38	8.29	55.49	5.86	55.00
...	....	....	**16.00**	....	....	**4.00**	....
882	10.79	5.98	18.50	7.99	52.26	4.48	55.00
...	....	....	**15.00**	....	....	**4.00**	....
910	9.71	4.85	16.75	8.47	54.10	6.12	44.00
...	....	....	**15.00**	....	....	**4.50**	....
925	9.94	5.95	18.00	8.98	52.17	4.96	57.00
...	....	....	**15.00**	....	....	**3.50**	....
893	11.85	5.12	14.94	7.27	55.77	5.05	57.00
...	....	....	**15.00**	....	....	**4.00**	....
914	10.59	4.50	16.13	8.12	55.36	5.30	56.00
...	....	....	**14.50**	....	....	**4.50**	....
885	9.40	6.43	17.63	7.61	53.85	5.08	54.00
...	....	....	**15.00**	....	....	**4.00**	....
939	10.64	5.23	14.00	7.23	58.28	4.62	65.00
...	....	....	**10.00**	....	....	**2.00**	**65.00**
...	....	....	**14.44**	....	....	**3.81**	....
...	**10.39**	**5.36**	**16.42**	**7.80**	**54.66**	**5.18**	**63.50**
...	....	....	**12.6**	**2.8**	**41.5**	**4.5**	....
875	11.01	4.41	18.31	7.28	53.16	5.83	57.50
...	....	....	**16.50**	....	....	**5.00**	....
879	9.90	4.17	15.44	6.08	59.57	4.84	47.00
...	....	....	**15.00**	....	....	**4.00**	....
953	10.34	4.65	16.94	8.31	54.05	5.71	54.00
...	....	....	**15.50**	....	....	**4.75**	....
918	10.12	5.43	17.81	7.91	54.02	4.71	55.00
...	....	....	**15.00**	**8.00**	**52.00**	**3.50**	....

TABLE V.—ANALYSES OF COMMERCIAL FEEDS,

Station No.	Brand.	Retail Dealer.
	WHEAT PRODUCTS—*Concluded.* *Wheat Middlings—Concluded.*	
11824	Winter. Thompson Milling Co., Lockport, N. Y.	*Ansonia:* Ansonia Flour & Grain Co.
		Guaranty
11856*	Standard. Washburn-Crosby Co., Minneapolis, Minn	*Middletown:* Meech & Stoddard, Inc.
		Guaranty
		Average guaranty
		Average of analyses
		Average digestible
	RYE PRODUCTS.	
11858	Feed. Boutwell Milling & Grain Co., Troy, N. Y.	*Middletown:* Meech & Stoddard, Inc.
		Guaranty
11920	Feed. Hecker-Jones-Jewell Milling Co., New York	*New Haven:* Crittenden Benham Co.
		Guaranty
11823	Bay State Middlings. Bay State Milling Co., Winona, Minn	*Ansonia:* Ansonia Flour & Grain Co.
		Guaranty
11847	Middlings. Washburn-Crosby Co., Minneapolis, Minn	*Branford:* S. V. Osborne
		Guaranty
	BARLEY PRODUCTS.	
11891*	Mixed Feed. Ewart & Lake, Groveland, N. Y.	*Rockville:* Edward White
		Guaranty
11901	Feed. Shane Bros. & Wilson Co., Minneapolis, Minn	*Willimantic:* Willimantic Grain Co.
		Guaranty
11848	Ground Barley. Simpson Hendee Co., New York City	*Branford:* S. V. Osborne
		Guaranty
11821	Feed, Pillsbury's. Pillsbury Flour Mills Co., Minneapolis, Minn	*Ansonia:* Ansonia Flour & Grain Co.
		Guaranty
	MAIZE PRODUCTS. *Corn Gluten Feed.*	
11829	Buffalo. Corn Products Refining Co., New York.	*North Haven:* Co-operative Feed Co.
		Guaranty
11931	Buffalo. Corn Products Refining Co., New York.	*Torrington:* F. L. Wadhams
		Guaranty
11876	Globe. Corn Products Refining Co., New York.	*Unionville:* F. D. Lawton & Son
		Guaranty
11922	K. K. K. J. C. Hubinger Bros. Co., Keokuk, Iowa	*New Haven:* Crittenden Benham Co.
		Guaranty

* With screenings.

INSPECTION OF 1918—*Continued.*

Station No.	Pounds per Hundred.						Price per ton.
	Water.	Ash.	Protein (N. x 6.25)	Fiber.	Nitrogen-free Extract. (Starch, gum, etc.)	Ether Extract. (Crude Fat)	
11824	10.03	4.45	15.63	6.23	58.72	4.94	$48.00
....	....	....	**13.00**	....	....	**4.00**	....
11856	11.03	4.43	16.94	6.97	54.59	6.04	44.00
....	....	....	**14.00**	....	....	**4.00**	....
....	....	....	**14.83**	....	....	**4.21**	....
....	**10.41**	**4.59**	**16.85**	**7.13**	**55.69**	**5.35**	**50.92**
....	....	....	**13.0**	**2.1**	**43.4**	**4.7**	....
11858	11.06	3.60	15.75	4.33	62.15	3.11	56.00
....	....	....	**13.50**	....	....	**3.00**	....
11920	9.88	3.78	15.44	4.56	63.35	2.99	60.00
....	....	....	**15.00**	**5.50**	**62.90**	**2.50**	....
11823	8.82	4.33	16.25	5.32	61.55	3.73	58.00
....	....	....	**16.00**	....	....	**3.40**	....
11847	8.98	4.00	17.31	5.30	60.79	3.62	58.00
....	....	....	**14.00**	....	....	**3.00**	....
11891	10.63	3.93	12.69	8.49	61.21	3.05	57.00
....	....	....	**12.00**	**10.00**	....	**2.00**	....
11901	9.01	5.70	10.19	15.43	56.59	3.08	51.00
....	....	....	**9.50**	**20.30**	....	**4.20**	....
11848	10.85	2.50	11.69	5.01	67.26	2.69	58.00
....	....	....	....	....	....	....	....
11821	8.21	5.93	11.69	15.63	55.17	3.37	54.00
....	....	....	**9.00**	....	....	**3.00**	....
11829	9.37	3.80	24.19	7.14	50.26	5.24	56.00
....	....	....	**23.00**	....	....	**1.00**	....
11931	8.58	5.65	26.38	6.43	49.95	3.01	66.00
....	....	....	**23.00**	....	....	**1.00**	....
11876	9.16	2.97	22.44	7.33	52.44	5.66	60.00
....	....	....	**23.00**	....	....	**1.00**	....
11922	8.80	1.45	21.88	5.71	57.97	4.19	62.00
....	....	....	**23.00**	**7.50**	....	**2.40**	....

TABLE V.—ANALYSES OF COMMERCIAL FEEDS,

Station No.	Brand.	Retail Dealer.
	MAIZE PRODUCTS—*Concluded.* *Corn Gluten Feed—Concluded.*	
11935	Piel Bros. Starch Co., Indianapolis, Ind........	*Thomaston:* L. E. Blackma
		Guaranty................
		Average guaranty........
		Average of analyses.......
		Average digestible........
	Hominy Feed.	
11851	Spring Garden. Baltimore Pearl Hominy Co., Baltimore, Md..............................	*West Cheshire:* G. W. Thorp
		Guaranty................
11952	M. F. Baringer, Philadelphia, Pa..............	*Stamford:* W. L. Crabb...
		Guaranty................
11839	Bufceco. Buffalo Cereal Co., Buffalo, N. Y....	*Meriden:* Meriden Grain & Feed Co..............
		Guaranty................
11937	Yellow. Buffalo Cereal Co., Buffalo, N. Y.....	*Thomaston:* L. E. Blackma
		Guaranty................
11869	Badger. Chas. A. Krause Milling Co., Milwaukee, Wis..................................	*Plantsville:* C. A. Cowles..
		Guaranty................
11828	Patent Cereals Co., Geneva, N. Y............	*North Haven:* Co-operative Feed Co..............
		Guaranty................
11907	Logan. The Standard Cereal Co., Chillicothe, O.	*Yantic:* A. R. Manning...
		Guaranty................
		Average guaranty........
		Average of analyses.......
		Average digestible........
	Corn Feed Meal.	
11929	Washburn-Crosby Co., Minneapolis, Minn......	*Winsted:* E. Manchester & Sons..................
		Guaranty................
	BREWERY AND DISTILLERY PRODUCTS. *Brewers' Grains.*	
11867	Bull. Farmers Feed Co., Buffalo, N. Y........	*Plantsville:* C. A. Cowles..
		Guaranty................
11845†	Dried grains. James Hawley Brewing Co., Providence, R. I...............................	*Branford:* S. V. Osborne...
		Guaranty................
11846	Dried grains. Providence Brewing Co., Providence, R. I...............................	*Branford:* S. V. Osborne...
		Guaranty................
		Average of analyses.......
		Average digestible........
	Distillers' Grains.	
11903	Dried Grains. Fleishman Co., Chicago, Ill......	*Willimantic:* Willimantic Grain Co.............
		Guaranty................

† Wired tags.

INSPECTION OF 1918—*Continued.*

tation No.	Pounds per Hundred.						Price per ton.
	Water.	Ash.	Protein (N. x 6.25)	Fiber.	Nitrogen-free Extract. (Starch, gum, etc.)	Ether Extract. (Crude Fat)	
1935	10.58	3.90	23.75	6.75	53.06	1.96	$67.00
....	....	....	**23.00**	**8.00**	....	**2.00**	....
....	....	....	**23.00**	....	....	**1.48**	....
....	**9.30**	**3.55**	**23.73**	**6.67**	**52.74**	**4.01**	**62.20**
....	....	....	**20.2**	**5.1**	**46.4**	**3.4**	....
1851	9.11	3.00	10.69	5.73	65.18	6.29	62.00
....	....	....	**10.00**	**6.00**	....	**5.00**	....
1952	8.90	7.61	10.81	4.99	59.64	8.05	72.00
....	....	....	**9.00**	....	....	**6.00**	....
1839	7.85	2.70	10.94	5.26	67.28	5.97	72.00
....	....	....	**10.00**	**5.00**	....	**6.00**	....
1937	11.80	5.05	10.06	3.17	65.37	4.55	67.00
....	....	....	**10.00**	**4.00**	**65.00**	**5.00**	....
1869	9.22	2.49	10.50	4.18	67.55	6.06	65.00
...	....	....	**10.00**	....	....	**6.00**	....
1828	9.66	2.42	11.13	4.47	65.28	7.04	60.00
...	....	....	**10.00**	....	....	**5.00**	....
1907	8.26	2.09	10.13	4.05	67.95	7.52	70.00
...	....	....	**9.00**	**6.00**	**60.00**	**7.00**	....
....	....	....	**9.71**	....	....	**5.71**	....
...	**9.26**	**3.62**	**10.61**	**4.55**	**65.46**	**6.50**	**66.86**
...	....	....	**7.0**	**3.5**	**58.9**	**5.9**	....
1929	10.51	2.38	10.25	4.67	64.96	7.23	68.00
...	....	....	**8.00**	....	....	**5.00**	....
.867	6.26	3.35	25.63	13.58	43.67	7.51	65.00
...	....	....	**27.20**	....	....	**6.30**	....
.845	6.16	4.36	19.31	17.06	45.95	7.16	58.00
...	....	....	**20.00**	**18.00**	....	**6.00**	....
.846	6.38	3.10	29.25	12.01	42.03	7.23	58.00
...	....	....	**25.00**	**15.00**	....	**5.00**	....
...	**6.27**	**3.60**	**24.73**	**14.22**	**43.88**	**7.30**	**60.33**
...	....	....	**20.0**	**7.0**	**25.0**	**6.5**	....
.903	6.49	7.51	19.63	15.48	43.68	7.21	55.00
...	....	....	....	....	....	....	....

TABLE V.—ANALYSES OF COMMERCIAL FEEDS,

Station No.	Brand.	Retail Dealer.
	MISCELLANEOUS FEEDS.	
11865‡	Dried Beet Pulp. Continental Sugar Co., Blissfield, Mich.	*New Britain:* C. W. Lines Co.
		Guaranty
11894	Dried Beet Pulp. Max Hottelet, Milwaukee, Wis.	*Manchester:* Little & McKinney
		Guaranty
11949	Dried Beet Pulp. Larrowe Milling Co., Detroit, Mich.	*South Norwalk:* Samuel Roodner
		Guaranty
11863‡	Dried Beet Pulp. Mich. Sugar Co., Sebewaing, Mich.	*Middletown:* Meech & Stoddard, Inc.
		Guaranty
11831‡	Dried Beet Pulp. Mich. Sugar Co., Bay City, Mich.	*Wallingford:* A. E. Hall.
		Guaranty
11923‡	Dried Beet Pulp. Mich. Sugar Co., Alma, Mich.	*New Haven:* Crittenden-Benham Co.
		Guaranty
11916	Dried Beet Pulp. Owasso Sugar Co., Owasso, Mich.	*New London:* P. Schwartz Co.
		Guaranty
		Average guaranty
		Average of analyses
		Average digestible
11827	Velvet Bean Feed. C. M. Cox Co., Boston, Mass.	*North Haven:* Co-operative Feed Co.
		Guaranty
11859	Pioneer Velvet Bean Feed. Lyle & Lyle, Huntsville, Ala.	*Middletown:* Meech & Stoddard, Inc.
		Guaranty
11854	Beta Peanut Oil Meal. Oil Seeds Co., Bayonne, N. J.	*Middletown:* Meech & Stoddard, Inc.
		Guaranty
11942	Copra Cake Meal. M. F. Baringer, Philadelphia, Pa.	*East Haven:* F. A. Forbes.
		Guaranty
	PROPRIETARY MIXED FEEDS. *Horse, Dairy and Stock Feeds.*	
11855	Calf Meal. Blatchford Calf Meal Factory, Wauregan, Ill.	*Middletown:* Meech & Stoddard, Inc.
		Guaranty
11887	Red Horn Calf Meal. Hales & Edwards Co., Chicago, Ill.	*Rockville:* Edward White.
		Guaranty
11924	Purina Calf Chow. Purina Mills, St. Louis, Mo.	*New Haven:* Crittenden-Benham Co.
		Guaranty
11896	Schumacher's Calf Meal. Quaker Oats Co., Chicago, Ill.	*Manchester:* Little & McKinney
		Guaranty

‡ Sold, guaranteed and licensed by the Larrowe Milling Co., Detroit, Mich.

INSPECTION OF 1918—*Continued.*

Station No.	Price per Hundred.						Price per ton.
	Water.	Ash.	Protein (N. x 6.25)	Fiber.	Nitrogen-free Extract. (Starch, gum, etc.)	Ether Extract. (Crude Fat)	
1865	8.98	2.94	8.75	19.77	58.23	1.33	$50.50
....	....	....	**8.00**	**20.00**	**58.00**	**0.50**	....
1894	7.39	2.33	8.00	18.76	62.75	0.77	53.00
....	....	....	**8.00**	**20.00**	**60.00**	**0.50**	....
1949	6.74	2.88	9.44	18.53	61.78	0.63	60.00
....	....	....	**8.00**	....	....	**0.50**	....
1863	7.46	2.41	8.69	17.28	63.19	0.97	49.50
....	....	....	**8.00**	**20.00**	**58.00**	**0.50**	....
1831	7.65	3.18	8.88	18.48	61.33	0.48	50.00
....	....	....	**8.00**	**20.00**	**58.00**	**0.50**	....
1923	7.40	2.70	9.00	19.20	61.12	0.58	51.00
....	....	....	**8.00**	**20.00**	**58.00**	**0.50**	....
1916	3.84	3.04	9.25	19.61	62.68	1.58	52.00
....	....	....	**8.00**	**20.00**	**58.00**	**0.50**	....
....	....	....	**8.00**	....	....	**0.50**	....
....	**7.07**	**2.78**	**8.86**	**18.80**	**61.58**	**0.91**	**52.28**
....	....	....	**4.6**	**15.6**	**51.1**	....	....
1827	10.07	5.48	16.88	12.98	50.28	4.31	45.00
....	....	....	**17.00**	....	....	....	....
1859	9.65	4.60	16.56	13.42	52.43	3.34	43.00
....	....	....	**16.00**	**17.00**	**45.00**	**4.00**	....
1854	8.28	4.47	25.25	9.01	40.44	12.55	58.00
....	....	....	**30.00**	**8.00**	....	**7.00**	....
1942	8.98	5.40	19.44	8.93	46.24	11.01	55.00
....	....	....	**21.00**	....	....	**6.00**	....
1855	10.75	5.71	26.25	6.75	44.65	5.89	100.00
....	....	....	**24.00**	....	....	**5.00**	....
1887	11.03	4.00	15.50	2.19	63.09	4.19	100.00
....	....	....	**18.00**	....	....	**5.00**	....
1924	10.37	3.01	30.50	3.08	49.14	3.90	100.00
....	....	....	**33.00**	....	....	**4.00**	.....
1896	9.22	4.20	18.38	2.36	57.67	8.17	100.00
....	....	....	**18.00**	....	....	**8.00**	....

TABLE V.—ANALYSES OF COMMERCIAL FEEDS,

Station No.	Brand.	Retail Dealer.
	PROPRIETARY MIXED FEEDS—*Continued.* *Horse, Dairy and Stock Feeds—Continued.*	
11905	Ryde's Cream Calf Meal. Ryde & Co., Chicago, Ill.	*Willimantic:* Willimantic Grain Co. Guaranty
11941	Alfalfa Strong Horse Feed. Alfalfa Milling Co., Ft. Calhoun, Neb	*Waterbury:* Spencer Grain Co. Guaranty
11938	Bufceco Horse Feed. Buffalo Cereal Co., Buffalo, N. Y.	*Thomaston:* L. E. Blackman Guaranty
11917	Bufceco Steam Cooked Horse Feed. Buffalo Cereal Co., Buffalo, N. Y.	*New London:* P. Schwartz Co. Guaranty
11900	Barford's Ready Ration for Horses. Meech & Stoddard Inc., Middletown, Conn	*Hartford:* The Meech Northam Grain Co. Guaranty
11861	Green Velvet Horse Feed. Metropolitan Mills, New York	*Middletown:* Meech & Stoddard, Inc. Guaranty
11948	Peerless Horse Feed. Omaha Alfalfa Milling Co., Omaha, Neb.	*South Norwalk:* Samuel Roodner Guaranty
11945†	Emerald Horse Feed. Prairie State Milling Co., Chicago, Ill.	*Norwalk:* C. E. Slauson Co. Guaranty
11926	Purina Horse Feed with Molasses. Purina Mills, St. Louis, Mo.	*New Haven:* Crittenden-Benham Co. Guaranty
11899	Barford's Ready Ration for Growing Pigs. R. G. Davis & Sons, New Haven	*Hartford:* The Meech Northam Grain Co. Guaranty
11946	Go Tu It Hog Ration. Park & Pollard Co., Boston, Mass	*Norwalk:* C. E. Slauson Co. Guaranty
11919	Purina Pig Chow. Purina Mills, St. Louis, Mo.	*New Haven:* Crittenden-Benham Co. Guaranty
11940	H. & S. Horse, Mule & Dairy Feed. Dwight Hamlin, Pittsburgh, Pa	*Waterbury:* Spencer Grain Co. Guaranty
11884	Acme Stock Feed. Acme Evans Co., Indianapolis, Ind.	*Hazardville:* A. D. Bridges' Sons. Guaranty
11913	Sucrene Dairy Feed. American Milling Co., Peoria, Ill.	*Norwich:* Chas. Slosberg & Son. Guaranty
11902	Armour's Dairy Feed. Armour & Co., Chicago, Ill.	*Willimantic:* Willimantic Grain Co. Guaranty
11908	Pennant Stock Feed. E. W. Bailey & Co., Swanton, Vt.	*Yantic:* A. R. Manning Guaranty

† Wired tags.

INSPECTION OF 1918—*Continued.*

Station No.	Pounds per Hundred. Water.	Ash.	Protein (N. x 6.25)	Fiber.	Nitrogen-free Extract. (Starch, gum, etc.)	Ether Extract. (Crude Fat)	Price per ton.
1905	10.18	5.53	24.56	7.29	46.67	5.77	$100.00
....	....	....	**25.00**	....	....	**5.00**	....
1941	6.39	9.12	12.06	15.72	54.78	1.93	63.00
....	....	....	**8.00**	....	....	**3.00**	....
1938	9.23	3.60	10.44	10.27	62.45	4.01	68.00
....	....	....	**10.00**	**10.00**	....	**4.00**	....
1917	8.59	2.75	8.50	8.18	68.26	3.72	65.00
....	....	....	**9.00**	**9.00**	....	**4.00**	....
1900	6.05	5.65	11.13	17.64	55.44	4.09	60.00
....	....	....	**10.00**	**16.00**	**50.00**	**3.00**	....
1861	6.98	7.18	9.00	19.11	56.78	0.95	57.50
....	....	....	**9.00**	....	....	**0.50**	....
1948	7.33	6.25	10.56	12.27	61.31	2.28	58.00
....	....	....	**9.00**	....	....	**1.50**	....
1945	7.12	8.67	11.63	16.87	53.99	1.72	....
....	....	....	**10.00**	**12.00**	**50.00**	**2.00**	....
1926	6.41	5.15	11.00	14.40	60.38	2.66	66.00
....	....	....	**9.30**	....	....	**1.70**	....
1899	10.06	4.03	18.00	7.84	53.83	6.24	.....
....	....	....	**18.00**	**10.50**	**45.00**	**5.00**	....
1946	9.90	8.50	19.13	8.87	44.83	8.77	....
....	....	....	**15.00**	....	....	**6.00**	....
1919	9.19	6.93	13.25	12.21	54.86	3.56	77.00
....	....	....	**14.00**	**9.00**	....	**3.20**	....
1940	6.38	9.01	12.94	19.28	50.82	1.57	63.00
....	....	....	....	....	....	....	....
1884	8.80	4.40	9.69	12.65	60.47	3.99	58.00
....	....	....	**10.00**	....	....	**4.00**	....
1913	9.99	6.00	23.38	7.34	48.44	4.85	56.00
....	....	....	**16.50**	....	....	**3.50**	....
1902	7.38	6.00	22.50	13.61	44.66	5.85	68.00
....	....	....	**22.00**	....	....	**5.00**	....
1908	9.49	3.45	8.75	8.33	65.25	4.73	60.00
....	....	....	**10.00**	**10.00**	....	**6.50**	....

TABLE V.—ANALYSES OF COMMERCIAL FEEDS,

Station No.	Brand.	Retail Dealer.
	PROPRIETARY MIXED FEEDS—*Continued.* *Horse, Dairy and Stock Feeds—Continued.*	
11936	Bufceco Stock Feed. Buffalo Cereal Co., Buffalo, N. Y.	*Thomaston:* L. E. Blackmai Guaranty
11934	Bufceco Creamery Feed. Buffalo Cereal Co., Buffalo, N. Y.	*Thomaston:* L. E. Blackmai Guaranty
11825	Bufceco Chop Feed. Buffalo Cereal Co., Buffalo, N. Y.	*Shelton:* Ansonia Flour & Grain Co. Guaranty
11843	Triangle Dairy Feed. Chapin & Co., Hammond, Ind.	*Guilford:* Morse & Landon. Guaranty
11904	Unicorn Dairy Ration. Chapin & Co., Hammond, Ind.	*Willimantic:* Willimantic Grain Co. Guaranty
11881	Clover Leaf Stock Feed. Clover Leaf Milling Co., Buffalo, N. Y.	*Thompsonville:* Geo. S. Phelps & Co. Guaranty
11897	Clover Leaf Dairy Feed. Clover Leaf Milling Co., Buffalo, N. Y.	*Hartford:* The Meech Northam Grain Co. Guaranty
11909	Crosby's 1918 Dairy Ration. E. Crosby & Co., Brattleboro, Vt.	*Yantic:* A. R. Manning. Guaranty
11915	Economic Special Dairy Feed. Economic Feed Co., New York.	*New London:* P. Schwartz Co. Guaranty
11852	Eshelman's Stock Feed. John W. Eshelman, Lancaster, Pa.	*West Cheshire:* G. W. Thorpe Guaranty
11906	Grandin's Stock Feed. D. H. Grandin Milling Co., Jamestown, N. Y.	*Willimantic:* Willimantic Grain Co. Guaranty
11832	Gwinn's Dairy Feed. The Gwinn Milling Co., Columbus, O.	*Wallingford:* A. E. Hall. Guaranty
11889	Red Horn Dairy Feed. Hales & Edwards, Chicago, Ill.	*Rockville:* Edward White. Guaranty
11911	Haskell's Stock Feed. W. H. Haskell & Co., Toledo, O.	*Norwich:* Chas. Slosberg & Son. Guaranty
11838	Algrane Milk Feed. H. O. Co., Buffalo, N. Y.	*Meriden:* Meriden Grain & Feed Co. Guaranty
11840	Climax Dairy Feed. Internationl Sugar Feed Co., Minneapolis, Minn.	*Guilford:* Morse & Landon. Guaranty
11841	Ready Ration Dairy Feed. International Sugar Feed Co., Minneapolis, Minn.	*Guilford:* Morse & Landon. Guaranty
11892	Special Dairy Feed. International Sugar Feed Co., Minneapolis, Minn.	*Rockville:* Edward White. Guaranty
11834	Cream City Dairy Feed. Chas. A. Krause Milling Co., Milwaukee, Wis.	*Meriden:* August Grulich Est. Guaranty

INSPECTION OF 1918—*Continued.*

Station No.	Pounds per Hundred.						Price per ton.
	Water.	Ash.	Protein (N. x 6.25)	Fiber.	Nitrogen-free Extract. (Starch, gum, etc.)	Ether Extract. (Crude Fat)	
11936	9.48	3.47	10.63	9.23	63.21	3.98	$65.00
....	....	....	**10.00**	**12.00**	....	**4.00**	....
11934	9.20	4.30	17.75	10.58	53.59	4.58	67.00
....	....	....	**18.00**	**12.00**	....	**4.00**	....
11825	9.40	3.63	8.44	10.04	64.21	4.28	66.00
....	....	....	**8.00**	**11.00**	....	**4.00**	....
11843	7.24	6.62	23.00	10.81	46.44	5.89	65.00
....	....	....	**21.00**	....	....	**4.00**	....
11904	8.48	6.02	27.31	9.26	42.70	6.23	70.00
....	....	....	**26.00**	....	....	**5.00**	....
11881	7.50	5.20	12.13	16.17	53.90	5.10	67.00
....	....	....	**10.00**	....	....	**4.00**	....
11897	10.69	7.83	16.88	15.68	44.23	4.69	51.00
....	....	....	**13.50**	....	....	**3.50**	....
11909	8.73	3.68	20.38	18.48	42.58	6.15	65.00
....	....	....	**25.00**	**15.00**	**59.00**	**6.00**	....
11915	7.71	4.36	16.13	18.01	47.62	6.17	60.00
....	....	....	**18.00**	....	....	**4.00**	....
11852	9.36	4.30	11.50	11.37	59.53	3.94	67.00
....	....	....	**10.00**	....	....	**3.00**	....
11906	7.23	3.63	10.38	9.24	62.16	7.36	61.00
....	....	....	**9.00**	....	....	**5.00**	....
11832	9.81	5.98	18.69	8.09	52.41	5.02	45.00
....	....	....	**15.00**	....	....	**4.00**	....
11889	9.07	4.70	23.94	9.65	47.56	5.08	66.00
....	....	....	**25.00**	....	....	**4.00**	....
11911	9.81	2.50	8.31	6.49	69.29	3.60	61.00
....	....	....	**9.00**	....	....	**6.00**	....
11838	7.74	5.84	16.88	14.53	51.00	4.01	50.00
....	....	....	**14.00**	....	....	**4.00**	....
11840	7.79	8.68	13.38	15.51	49.61	5.03	50.00
....	....	....	**12.00**	....	....	**4.00**	....
11841	7.35	8.55	21.19	11.81	45.19	5.91	65.00
....	....	....	**20.00**	....	....	**5.00**	....
11892	10.75	8.71	14.56	14.04	46.29	5.65	59.00
....	....	....	**15.00**	....	....	**4.50**	....
11834	8.47	5.60	18.94	13.74	48.08	5.17	65.00
....	....	....	**19.00**	....	....	**4.50**	....

TABLE V.—ANALYSES OF COMMERCIAL FEEDS,

Station No.	Brand.	Retail Dealer.
	PROPRIETARY MIXED FEEDS—*Concluded.* *Horse, Dairy and Stock Feeds—Concluded.*	
11835	Krause Stock Feed. Chas. A. Krause Milling Co., Milwaukee, Wis.	*Meriden:* August Grulic Est.
		Guaranty.
11836	Badger Stock Feed. Chas. A. Krause Milling Co., Milwaukee, Wis.	*Meriden:* August Grulic Est.
		Guaranty.
11944	Nu Life Dairy Feed. Krisse & Co., Boston, Mass.	*Bridgeport:* Standard Fee Co.
		Guaranty.
11862	Larro Feed. The Larrowe Milling Co., Detroit, Mich.	*Middletown:* Meech & Stoc dard, Inc.
		Guaranty.
11870	Big Six. The Larrowe Milling Co., Detroit, Mich.	*Plainville:* Eaton Bros.
		Guaranty.
11850	M. & S. Stock Feed. Meech & Stoddard, Inc., Middletown, Conn.	*West Cheshire:* G. W. Thorp
		Guaranty.
11932	Domino, formerly Justice, Creamery Feed. Norwalk Milling Corp., Buffalo, N. Y.	*Torrington:* D. L. Talcott.
		Guaranty.
11886	Green Meadow Dairy Feed. Omaha Alfalfa Milling Co., Omaha, Neb.	*Hazardville:* A. D. Bridge Sons.
		Guaranty.
11872	Stevens 44 Dairy Ration. Park & Pollard Co., Boston, Mass.	*Bristol:* Goodsell Bros.
		Guaranty.
11921†	Purina Cow Chow Feed. Purina Mills, St. Louis, Mo.	*New Haven:* Crittender Benham Co.
		Guaranty.
11878	Big Q Dairy Ration. Quaker Oats Co., Chicago, Ill.	*Thompsonville:* G. S. Phel & Co.
		Guaranty.
11871	Schumacher's Feed. Quaker Oats Co., Chicago, Ill.	*Plainville:* Eaton Bros.
		Guaranty.
11868	Union Grains, Biles Ready Ration. The Ubiko Milling Co., Cincinnati, O.	*Plantsville:* C. A. Cowles.
		Guaranty.
11943	Diamond Dairy Feed No. 2. Viehman Grain Co., Minneapolis, Minn.	*East Haven:* F. A. Forbes.
		Guaranty.
	POULTRY FEEDS.	
11826	Bufceco Poultry Mash. Buffalo Cereal Co., Buffalo, N. Y.	*Shelton:* Ansonia Flour Grain Co.
		Guaranty.
11874	H-O Co.'s Poultry Feed. H. O. Co., Buffalo, N. Y.	*Bristol:* Goodsell Bros.
		Guaranty.
11933	Laying Mash. John W. Eshelman, Lancaster, Pa.	*Torrington:* D. L. Talcott.
		Guaranty.
11888	Red Comb Crate Fattener with Dried Buttermilk. Hales & Edwards, Chicago, Ill.	*Rockville:* Edward White.
		Guaranty.

† Wired tags.

INSPECTION OF 1918—*Continued.*

Station No.	Price per Hundred.						Price per ton.
	Water.	Ash.	Protein (N. x 6.25)	Fiber.	Nitrogen-free Extract. (Starch, gum, etc.)	Ether Extract. (Crude Fat)	
11835	8.36	3.65	9.44	10.06	63.49	5.00	$65.00
....	....	....	**10.00**	....	....	**4.50**	....
11836	7.20	5.38	11.25	15.08	56.81	4.28	60.00
....	....	....	**10.00**	....	....	**4.50**	....
11944	8.52	7.35	22.19	11.53	46.06	4.35	60.00
....	....	....	....	....	....	....	....
11862	9.63	4.38	20.50	11.08	49.41	5.00	64.00
....	....	....	**20.00**	**14.00**	**50.00**	**3.00**	....
11870	8.45	5.17	21.13	7.45	51.94	5.86	67.00
....	....	....	**21.00**	**12.00**	**48.00**	**4.00**	....
11850	8.67	4.59	9.56	9.16	63.80	4.22	57.00
....	....	....	**9.00**	....	....	**3.00**	....
11932	8.84	5.75	23.31	10.78	45.95	5.37	65.00
....	....	....	**24.00**	....	....	**4.00**	....
11886	6.47	10.13	12.38	19.95	50.14	0.93	55.00
....	....	....	**10.00**	....	....	....	....
11872	7.60	5.40	24.81	13.06	43.29	5.84	71.00
....	....	....	**24.00**	....	....	**5.00**	....
11921	8.20	6.45	24.44	10.89	45.57	4.45	76.00
....	....	....	**24.00**	**12.00**	**42.00**	**4.80**	....
11878	8.77	6.63	20.19	10.38	48.78	5.25	67.00
....	....	....	**21.00**	....	....	**5.00**	....
11871	8.34	4.73	11.75	10.42	61.04	3.72	58.00
....	....	....	**10.00**	....	....	**3.25**	....
11868	8.02	4.90	23.94	9.48	47.07	6.59	70.00
....	....	....	**24.00**	**10.00**	**50.00**	**5.00**	....
11943	8.83	8.62	11.63	21.71	42.76	6.45	48.00
....	....	....	**8.00**	....	....	**4.00**	....
11826	8.86	2.40	14.00	3.80	65.23	5.71	75.00
....	....	....	**15.00**	**5.60**	....	**4.00**	....
11874	9.10	3.70	19.38	6.25	55.68	5.89	64.00
....	....	....	**17.00**	**9.00**	....	**4.50**	....
11933	9.88	9.19	19.50	6.41	49.29	5.73	80.00
....	....	....	**20.00**	....	....	**5.00**	....
11888	11.18	4.78	15.44	5.55	58.50	4.55	80.00
....	....	....	**15.00**	....	....	**4.00**	....

TABLE V.—ANALYSES OF COMMERCIAL FEEDS,

Station No.	Brand.	Retail Dealer.
	POULTRY FEEDS—*Concluded.*	
11860	M. & S. Dry Mash. Meech & Stoddard, Inc., Middletown, Conn.	*Middletown:* Meech & Stoddard, Inc. Guaranty
11912	Mystic Laying Mash. Mystic Milling & Feed Co., Rochester, N. Y.	*Norwich:* Chas. Slosberg & Son Guaranty
11928	Growing Feed. Park & Pollard Co., Boston, Mass.	*New Haven:* F. S. Platt Co. Guaranty
11898	Lay or Bust Feed (Dry Mash). Park & Pollard Co., Boston, Mass.	*Hartford:* The Meech Northam Grain Co. Guaranty
11927	Platt's Laying Mash. F. S. Platt Co., New Haven, Conn.	*New Haven:* F. S. Platt Co. Guaranty
11837	Tom Boy Poultry Mash. Purity Oats Co., Davenport, Iowa	*Meriden:* Meriden Grain & Feed Co. Guaranty
11947	Ful-O-Pep Dry Mash. Quaker Oats Co., Chicago, Ill.	*Norwalk:* C. E. Slauson Co. Guaranty
11833	Chic Chuck Poultry Feed. Russia Cement Co., Gloucester, Mass.	*Wallingford:* A. E. Hall Guaranty
11950	Ti-O-Ga Laying Food. Tioga Mill & Elev. Co., Waverly, N. Y.	*Stamford:* W. L. Crabb Guaranty

INSPECTION OF 1918—*Concluded.*

Station No.	Pounds per Hundred.						Price per ton.
	Water.	Ash.	Protein (N. x 6.25)	Fiber.	Nitrogen-free Extract. (Starch, gum, etc.)	Ether Extract. (Crude Fat)	
11860	10.23	6.60	19.25	5.69	53.70	4.53	$75.00
....	....	....	**12.00**	**8.00**	....	**3.00**	....
11912	9.31	7.80	18.94	12.68	45.82	5.45	79.00
....	....	....	**23.00**	....	....	**4.00**	....
11928	11.10	4.30	12.56	5.12	63.25	3.67	86.00
....	....	....	**10.00**	....	....	**1.50**	....
11898	10.40	8.22	19.38	7.03	51.72	3.25	83.00
....	....	....	**18.00**	**12.00**	**40.00**	**1.50**	....
11927	10.36	11.20	18.94	5.13	48.99	5.38	84.00
....	....	....	**20.00**	....	....	**5.50**	....
11837	7.69	5.05	16.19	8.98	57.22	4.87	82.00
....	....	....	**15.00**	**10.00**	....	**4.00**	....
11947	9.03	9.00	21.00	8.35	46.82	5.80	....
....	....	....	**20.00**	....	....	**4.00**	....
11833	6.87	37.13	52.13	1.81	0.73	1.33	88.00
....	....	....	**50.00**	....	....	**2.00**	....
11950	8.57	16.79	20.19	5.53	44.27	4.65	66.00
....	....	....	**16.00**	....	....	**2.50**	....

TABLE VI.—INSPECTION OF

No.	Brand.	Net weight of package.	Price per package.	Price per pound.	Chemical Analysis. Water.	Ash.	Nitrogen.	Nitrogen as nitrate.	Crude fiber.	Ether extract
		lbs.	cts.	cts.	%	%	%		%	%
11495	Dr. Hess Stock Tonic........ Dr. Hess & Clark, Ashland, Ohio.	2.0	25	13	7.58	36.32	0.67	present	22.61	0.2
11497	Dr. Hess Worm Powder...... Dr. Hess & Clark, Ashland, Ohio.	1.5	50	33	12.17	27.83	0.44	none	24.71	0.7
11500	O H Calves' Cordial......... Our Husbands Mfg. Co., Lyndon, Vt.	1.0	35	35	6.83	65.30	0.17	none	9.65	0.4
11506	Pratt's Animal Regulator..... Pratt Food Co., Philadelphia, Pa.	1.3	25	19	7.16	18.55	0.96	none	39.43	7.2
11507	Pratt's Conditioner.......... Pratt Food Co., Philadelphia, Pa.	7.0	50	7	7.25	17.12	0.92	trace	41.58	7.
11505	Pratt's Worm Powder........ Pratt Food Co., Philadelphia, Pa.	0.8	50	66	6.67	14.58	1.05	trace	38.68	1.
11508	Pratt's Baby Chick Food..... Pratt Food Co., Philadelphia, Pa.	2.5	30	12	10.41	9.54	2.14	present	3.12	5.
11504	Chicure Egg Producer........ King Remedy Co., Rochester, N. Y.	1.5	25	17	4.25	51.50	2.60	present	3.91	11.
11503	Salovet Poultry Tonic........ The S. R. Feil Co., Cleveland, Ohio.	1.5	25	17	4.72	56.25	0.65	trace	23.92	3.4
11502	Conkey's Laying Tonic....... G. E. Conkey Co., Cleveland, Ohio.	...	25	..	5.60	27.50	1.26	present	39.13	11.
11498	Rust's Egg Producer......... William Rust & Sons, New Brunswick, N. J.	2.5	50	20	5.83	58.53	3.13	present	4.88	3.
11496	Pratt's Poultry Regulator.... Pratt Food Co., Philadelphia, Pa.	1.5	25	17	5.26	23.38	1.02	trace	37.40	7.
11494	Dr. Hess Poultry Panacea.... Dr. Hess & Clark, Ashland, Ohio.	1.5	25	17	8.52	28.65	0.46	present	23.88	0.
10550	Scour Cure................. Manufacturer unknown.	...	..	..	95.19*	0.09	....	....	.....	...

* Water and volatile.

CONDIMENTAL FOODS AND REMEDIES.

Ingredients Declared or Claims Made.	Vegetable and Mineral Ingredients Found.
'ontains blood-builders, tonics, laxatives and worm expellers..........	Charcoal; fenugreek; quassia; nux vomica; aconite(?); gentian indicated; ground cotton hulls; Epsom salt; Glauber's salt(?); common salt; saltpeter.
or horses, cattle, hogs, sheep and poultry..........................	Quassia; cinchona; cotton hulls; weed seeds; salt; sulphates; iron and magnesium.
lixture of four ingredients that make a corrective for any unnatural condition of stomach and bowels........	Charcoal; ginger; alkaloids not found; bitter principles none; bicarbonate of soda; sulphates; calcium; magnesium; iron and aluminum.
ree from all poisons and injurious drugs. Acts on the blood, bowels and digestive organs..............	Fenugreek; charcoal; nux vomica; quassia; ginger indicated; Epsom salt; common salt; iron.
'onic for horses, cattle and sheep....	Gentian; quassia; nux vomica; ground hulls resembling buckwheat hulls; Epsom salt; common salt; saltpeter probably; iron and calcium.
:ills and expels worms. Strong tonic. Sure remedy.....................	Cinchona; *quassia*; *nux* vomica; charcoal; red pepper indicated; weed seeds; Venetian red; phosphates.
rotein 11.50 per cent.; fat 3.50; crude fiber 3.80. Corn meal, wheat and oat middlings, cooked wheat, bone meal, shell meal, millet, pepper, rape.....	Fenugreek; pepper; bitter principle none; wheat; corn; bran; rape; millet; ground shells; Epsom salt; nitrates.
uaranteed to produce eggs.........	Pepper; sulphur; Venetian red; ground shells; salt; saltpeter; sulphates; magnesium.
harcoal, cayenne pepper, copperas, Glauber's salt, Epsom salt, fenugreek, salt, anise, quassia, sulphur, bicarbonate of soda, saltpeter, iron oxide, carbonate of lime...........	Pepper; sulphur; fenugreek; bitter principle; charcoal; Epsom salt; nitrates; ferrous sulphate; ground shells.
ledicine, contains no filler, should be used in small quantities only......	Pepper; sulphur; bitter principle; charcoal; rape seed; bicarbonate of soda; sulphates; sulphites; chlorides; nitrates.
'on-nutritive, not a feeding stuff....	Pepper; sulphur; bitter principle; ginger *indicated*; ground shells; phosphates (bone); sulphates; nitrates; iron; magnesium.
medicinal tonic, no nutritive properties...........................	Pepper; sulphur, small amount;. fenugreek; bitter principle; ginger; ground shells.
otassium nitrate, quassia, sulphate of iron, calcium carbonate, nux vomica, sodium hyposulphite, sodium chloride, Venetian red................	Venetian red; sulphur(?); quassia; nux vomica; ground cotton hulls; saltpeter; ferrous sulphate; salt; sodium hyposulphite; ground limestone.
....	Capsicum; ginger(?); phenolic compounds; opium alkaloids; mineral medicaments, none or trace.

Connecticut Agricultural Experiment Station

NEW HAVEN, CONN.

BULLETIN 213 JULY, 1919

ECONOMY IN FEEDING THE FAMILY

V

Condensed Milk, Malted Milk Milk Powder

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Condensed or Evaporated Milks, Malted Milks and Milk Powders.

By John Phillips Street
Chemist in Charge of Analytical Laboratory.

Condensed Milk.

The words "condensed" and "evaporated" as applied to milk have been rather loosely used in the past. The term "evaporated" has generally been applied to milk which had been concentrated by evaporation under reduced pressure with more or less heat, but without the addition of any cane sugar. The term "evaporated cream" was always a misnomer, as the product was similar to cream only in consistency. Legal enactments and the practice of the better class of manufacturers have made this term obsolete. "Condensed" milk, on the other hand, is popularly applied to evaporated milk to which more or less cane sugar has been added to aid in its preservation. Certain brands, however, are found on the market where the original significance of the two terms is entirely lost, and confusion has accordingly resulted. The Federal Committee on Food Definitions and Standards recognizes the terms "condensed" and "evaporated" as applied to milk as synonymous, and suggests the use of the prefixes "sweetened" or "unsweetened" as the case may be, to prevent misunderstanding. The numerical standards now in force for these products are as follows:

Condensed milk contains not less than 25.5 per cent. of total solids and not less than 7.8 per cent. of milk fat.

Sweetened condensed milk contains not less than 28.0 per cent. of total milk solids and not less than 8.0 per cent. of milk fat.

Condensed skimmed milk contains not less than 20.0 per cent. of milk solids.

Sweetened condensed skimmed milk contains not less than 28.0 per cent. of milk solids.

It is obvious that the quality of a condensed milk depends upon the quality of the original milk, upon the degree of concentration, and upon the skill with which this concentration is ef-

TABLE I—CONDENSED MILK (UNSWEETENED).

Date of analysis.	Brand and Manufacturer.	Water.	Ash.	Protein (N x 6.38).	Milk Sugar.	Fat.	Calories per 100 gms.
1916	Armour & Co. Veribest........	74.57	1.58	6.38	9.80	7.67	134
1919	" " " "	74.94	1.58	6.67	8.55	8.26	135
1905	Borden's Cond. Milk Co. Peerless	70.97	.....	.....	.....	7.55	...
1906	" " " " "	73.68	1.52	6.95	10.25	7.60	137
1909	" " " " "	69.21	1.71	8.36	11.45	9.27	163
1916	" " " " "	73.72	1.39	6.64	9.82	8.43	142
1919	Carnation Milk Prod. Co. Carnation.....................	74.29	1.34	6.70	8.10	9.57	145
1916	Delavan Cond. Milk Co. Beauty	74.04	1.53	6.83	9.49	8.11	138
1909	Federal Packing Co. Hylac....	70.13	1.70	8.17	9.80	10.20	164
1909	Gt. Atl. & Pac. Tea Co. A. & P.	71.54	1.43	7.66	10.80	8.57	151
1916	" " " "	74.07	1.50	6.57	9.85	8.01	138
1906	Helvetia Milk Cond. Co. Highland........................	69.70	1.85	8.31	11.46	8.68	157
1909	Helvetia Milk Cond. Co. Highland........................	70.60	1.60	7.85	10.95	9.00	156
1906	Helvetia Milk Cond. Co. Our Pet	73.66	1.58	6.86	10.43	7.47	136
1909	" " " " "	71.62	1.63	7.08	10.71	8.96	152
1916	" " " " "	71.82	1.69	7.53	10.63	8.33	148
1916	Highland Milk Cond. Co. Honor	71.29	1.48	7.08	11.39	8.76	153
1916	" " " "	71.95	1.53	7.08	10.54	8.90	151
1906	Hires Cond. Milk Co. Gold....	75.19	1.49	7.22	10.49	5.61	121
1916	" " " " ...	73.72	1.52	7.27	9.59	7.90	139
1909	Indiana Cond. Milk Co. Wilson's	75.27	1.53	6.70	8.75	7.75	132
1916	" " " "	73.45	1.51	7.91	8.55	8.58	143
1909	Libby, McNeil & Libby. Libby's	74.08	1.50	7.15	9.39	7.88	137
1916	Mohawk Cond. Milk Co. Gold Cross......................	72.72	1.75	7.91	9.58	8.04	142
1916	Morris & Co. Supreme........	73.05	1.60	6.51	10.73	8.11	142
1916	National Cond. Milk Co. Globe	72.60	1.57	7.02	10.84	7.97	143
1916	Pacific Coast Cond. Milk Co. Carnation..................	73.75	1.49	6.76	9.89	8.11	140
1906	Scranton Cond. Milk Co. Gilt Edge......................	70.11	1.70	8.60	11.99	7.60	151
1916	Seminole Cond. Milk Co. Belle Brook.....................	72.94	1.62	6.57	10.83	8.04	142
1916	Seminole Cond. Milk Co. Lake View......................	73.83	1.60	6.44	10.08	8.05	139
1906	St. Charles Cond. Co. Silver Cow	70.09	1.81	8.31	11.31	8.48	155
1909	" " " " "	70.86	1.72	8.17	10.63	8.62	153
1906	" " " St. Charles	68.93	1.80	8.75	11.86	8.66	160
1909	" " " " "	71.58	1.34	7.66	10.55	8.87	153
1905	Van Camp Pack. Co. Top Notch	71.37	.....	.....	.....	7.10	...
1906	" " " " "	73.49	1.53	7.05	10.45	7.48	137
1909	" " " Van Camp's	74.85	1.29	6.89	9.77	7.20	131
1910	" " " " "	.....	.....	.....	.....	8.41	...
1911	" " " " "	71.23	.....	.....	.....	9.35	...
1916	" " " " "	72.90	1.69	6.76	10.65	8.00	142
1909	Wayne Co. Cond. Milk Co. Blue Label......................	70.98	1.57	7.53	10.93	8.99	155
1916	Wisconsin Cond. Milk Co. Lion..	74.48	1.45	6.70	9.38	7.99	136

TABLE II—CONDENSED MILK (SWEETENED.)

Brand and Manufacturer.	Water.	Cane sugar.	Ash.	Protein (N x 6.38).	Milk sugar.	Fat.	Calories per 100 gms.
Allen-Ditchett Co. The Best	28.03	38.57	1.90	9.12	15.48	6.90	315
Amer. Cond. Milk Co. Anchor	26.97	37.88	1.97	9.28	14.44	9.46	332
" " " Blue Bell	26.50	37.94	1.95	9.50	14.80	9.31	333
C. Andresen & Co. Andresen's Best	24.69	41.62	2.10	9.81	14.43	7.35	330
Aylwer Cond. Milk Co. Canada First	28.93	39.62	1.56	7.53	13.30	9.06	323
Aurora Cond. Milk Co. Aurora	25.39	42.10	1.75	7.85	12.91	10.00	341
Bennett, Sloan & Co. Valley Farm	24.86	42.13	1.91	9.12	13.28	8.70	336
Berna Milk Co. Swiss Milk Berna	25.01	37.52	2.02	8.36	*17.12	9.97	342
Bernese Alps Milk Co. Swiss Milk	23.72	41.73	1.86	8.17	14.91	9.61	346
Borden's Cond. Milk Co. Baby	25.00	39.97	1.87	8.71	14.42	10.03	343
" " " "	27.62	40.61	1.73	7.91	12.53	9.60	331
" " " "	27.55	40.84	1.72	8.17	12.96	8.76	327
" " " Challenge	24.84	43.42	1.92	8.57	13.02	8.23	334
" " " "	31.32	29.22	1.82	8.10	*20.24	9.30	314
" " " "	25.02	39.88	1.88	7.98	15.45	9.79	341
" " " Dairy	25.22	43.42	1.60	8.10	12.08	9.58	341
" " " Daisy	29.32	40.47	1.75	7.82	12.13	8.51	318
" " " "	26.28	43.45	1.50	8.17	11.50	9.10	334
" " " "	26.08	41.80	1.79	7.52	14.24	8.57	331
" " " Darling	26.95	43.43	1.70	7.85	10.42	9.65	334
" " " Defiance	26.75	39.81	1.93	8.99	13.09	9.43	331
" " " "	26.13	40.91	1.73	8.47	13.13	9.63	337
" " " "	23.97	42.22	2.00	7.72	15.03	9.06	341
" " " Dime	27.85	39.44	1.77	7.77	14.26	8.91	326
" " " "	27.21	37.49	1.79	7.65	17.42	8.44	326
" " " Dirigo	24.91	41.22	1.90	9.03	13.06	9.88	342
" " " Dixie	26.06	38.41	1.81	8.04	*16.51	9.17	334
" " " Eagle	25.99	42.93	1.86	8.15	12.35	8.72	332
" " " "	24.87	44.03	1.86	8.04	11.95	9.25	339
" " " "	26.26	39.90	1.70	7.59	15.76	8.79	333
" " " Full Weight	23.85	41.00	1.95	8.80	14.95	9.45	344
" " " Leader	28.82	41.35	1.74	7.87	11.53	8.69	321
" " " Magnolia	27.17	42.24	1.78	7.95	12.52	8.34	326
" " " "	23.81	42.11	1.76	8.80	13.66	9.86	347
" " " "	26.66	42.16	1.75	7.85	13.09	8.49	329
" " " O. K.	25.78	36.56	1.89	8.72	*17.30	9.75	338
" " " Pine Tree	29.89	32.97	1.64	7.98	*18.50	9.02	319
" " " Stag	23.67	43.70	1.97	9.16	12.54	8.96	342
" " " Star	31.72	38.52	1.66	8.20	10.80	9.10	312
" " " Thistle	25.16	41.12	1.86	8.10	13.70	10.06	342
" " " Tip Top	21.67	41.76	2.15	9.35	15.00	10.07	355
" " " " "	25.08	39.94	1.88	8.29	15.24	9.57	340
" " " Winner	25.26	42.34	1.81	8.87	12.06	9.66	340
Bridgeton Cond. Milk Co. Epicure	29.38	30.14	1.66	7.31	*23.18	8.33	317
Champlain Cond. Milk Co. Champlain	29.30	39.11	1.71	7.85	12.43	9.60	324
Clark's Summit D. & C. Co. Apple Blossom	27.65	32.01	1.88	8.46	*20.60	9.40	329

esults probably too high due to a partial inversion of cane sugar.

TABLE II—CONDENSED MILK (SWEETENED)—*Continued.*

Date of analysis.	Brand and Manufacturer.	Water.	Cane sugar.	Ash.	Protein (N x 6.38).	Milk sugar.	Fat.	Calories per 100 gms.
1919	Diamond Creamery Co. Honeysuckle	28.52	40.28	1.69	7.88	12.03	9.60	327
1916	Direct Impt. Co. Benefit...........	29.57	40.60	1.65	7.91	12.01	8.26	316
1909	Emery Food Co. Emery...........	28.89	39.23	1.54	8.61	12.84	8.89	323
1904	Gt. Atl. & Pac. Tea Co. Grandmother's A. & P.................	27.27	40.09	1.87	8.88	13.53	8.36	325
1909	Gt. Atl. & Pac. Tea Co. Grandmother's A. & P.................	28.84	29.64	1.75	7.91	*22.85	9.01	323
1916	Gt. Atl. & Pac. Tea Co. Grandmother's A. & P.................	26.15	43.22	1.64	7.52	12.63	8.84	333
1904	Dr. Hand Cond. Milk Co. Dr. Hand's	26.97	38.63	2.16	9.36	14.07	8.81	328
1909	" " " " " "	29.75	35.34	1.99	8.43	*16.55	7.94	313
1916	Holland Food Corp. Milkman........	25.67	39.44	2.08	8.68	14.98	9.15	335
1909	M. B. & F. S. Hubbell. Gilead.....	30.21	36.75	1.62	8.10	14.14	9.18	327
1916	Hudson Cond. Milk Co. Kitten....	27.68	26.99	1.99	8.49	*24.68	10.17	332
1919	International Milk Prod. Co. Dairy Queen.........................	27.32	43.90	1.68	7.44	10.66	9.00	329
1916	Libby, McNeil & Libby. Libby's...	23.61	43.90	1.79	8.36	13.02	9.32	349
1919	" " " " ...	26.09	43.99	1.81	7.37	12.40	8.34	330
1919	" " " " ...	25.76	45.21	1.61	7.98	10.98	8.46	333
1904	Michigan Cond. Milk Co. Peninsular	26.38	41.72	1.86	8.60	13.20	8.24	328
1909	" " " Star......	25.79	42.36	1.78	8.49	12.59	8.99	335
1916	Mohawk Cond. Milk Co. Gold Medal	27.46	43.30	1.66	6.95	12.22	8.41	325
1904	" " " Sweet Clover	24.07	43.09	1.87	8.71	12.95	9.31	343
1909	" " " " "	24.29	42.97	1.79	8.74	12.26	9.95	345
1909	" " " " "	24.73	44.05	1.59	8.42	11.82	9.39	342
1916	" " " " "	26.52	41.20	1.67	8.42	13.21	8.98	332
1904	Henri Nestlé. Nestlé's.............	25.76	38.70	1.90	8.70	15.37	9.57	337
1904	Scranton Cond. Milk Co. Gilt Edge..	25.48	41.13	1.85	8.72	13.86	8.96	336
1904	" " " Red Line...	27.45	39.60	1.93	8.98	14.80	7.24	319
1916	Seminole Cond. Milk Co. Butler's...	25.28	43.81	1.76	7.78	12.45	8.92	336
1916	" " " Essie......	23.61	46.02	1.92	7.27	12.95	8.23	339
1904	U. S. Cond. Milk Co. Empire State..	26.09	40.80	1.83	8.14	14.11	9.03	333
1904	" " " Regal........	27.02	40.33	1.85	7.96	13.91	8.93	329
1904	" " " Upper Ten....	27.88	38.47	1.85	8.34	14.66	8.80	325
1909	Vermont Cond. Milk Co. Ruby.....	26.58	40.68	1.65	8.23	12.82	10.04	337
1909	" " " Silver Chord	25.46	42.33	1.91	8.49	12.30	9.51	338
1909	" " " Vermont..	25.90	40.97	1.71	8.36	13.80	9.26	336
1909	" " " " ..	25.41	43.56	1.62	8.23	11.57	9.61	340
1909	" " " " ..	28.17	40.54	1.70	8.43	11.28	9.88	330
1909	Wayne Co. Cond. Milk Co. Pride of Wayne.........................	24.52	44.83	1.63	8.36	12.29	8.37	337
1904	Wisconsin Cond. Milk Co. Arrow...	26.83	42.02	1.79	8.49	12.87	8.00	326
1916	" " " Lion....	29.53	39.93	1.70	7.91	12.21	8.72	319
	Average (84 analyses).......	**26.62**	**40.34**	**1.80**	**8.29**	**14.00**	**8.95**	**332**
	Maximum.................	**31.72**	**45.21**	**2.16**	**9.81**	**24.68**	**10.17**	**355**
	Minimum.................	**21.67**	**26.99**	**1.50**	**6.95**	**10.42**	**6.90**	**312**

*Results probably too high due to a partial inversion of cane sugar.

CONDENSED SKIMMED MILK (SWEETENED).

analysis.	Brand and Manufacturer.	Water.	Cane sugar.	Ash.	Protein (N x 6.38).	Milk sugar.	Fat.	Calories per 100 gms.
6	M. Darlington's Sons. Marvel......	28.60	48.22	1.86	8.29	12.36	0.67	282
.6	Foster Packing Co. Target.........	26.32	38.63	1.90	8.74	23.37	1.04	292
.9	Merton Dairy Prod. Co. Value.....	29.27	30.42	2.33	9.80	27.02	1.16	279
.6	Hires Cond. Milk Co. Square......	28.34	47.45	1.71	8.36	13.28	0.86	284
9	Northville Milk Cond. Co. Domestic	30.16	42.72	2.34	10.05	13.06	1.67	278
6	South Holland Milk Corp. Van Troup	29.80	37.83	2.19	9.57	20.00	0.61	276
	Average....................	**28.74**	**40.88**	**2.05**	**9.14**	**18.18**	**1.01**	**282**

MALTED MILKS.

Seven samples, representing four brands, have been analyzed. These are mixtures of dried milk and malted cereals. They contain practically no unaltered starch and accordingly are of value to persons with impaired digestion.

TABLE III—MALTED MILK.

Date of analysis.	Brand and Manufacturer.	Water.	Fat.	Fiber.	Ash.	Protein (N x 6.25).	Nitrogen-free extract.	Calories per 100 gms.
1915	A. D. S..................	5.93	6.75	0.13	3.08	14.06	70.05	397
1908	Borden's.................	5.42	6.14	0.23	3.17	13.38	71.66	395
1915	"	5.18	7.15	0.05	3.45	15.38	68.79	401
1908	Horlick's................	3.63	8.36	0.00	3.70	12.94	71.37	412
1915	"	2.03	8.10	0.15	4.00	15.00	70.72	416
1908	Meadow's................	4.04	4.11	0.26	3.22	13.88	74.49	390
1915	"	3.20	5.20	0.30	3.28	14.50	73.52	399

DRIED MILKS, OR MILK POWDERS.

Analyses of seven brands are shown in Table IV. As a rule these represent milks from which more or less of the original fat has been removed. This has been done with no fraudulent intent, but rather because a skimmed milk is more easily dried than a whole milk and the resultant product has superior keeping qualities.

TABLE IV—DRIED MILK.

Date of analysis.	Brand and Manufacturer.	Water.	Ash.	Protein (N x 6.38).	Fat.	Lactose.	Calories per 100 gms.
1913	Klim. Merrell-Soule Co.	2.56	8.10	37.07	2.23	50.04	369
1918	Krystalak. Dry Milk Co.	5.05	8.37	35.41	3.20	47.97	363
1918	Lactora. Dry Milk Co.	8.39	7.74	32.47	2.60	48.80	348
1914	Mammala. Mammala Corp.	5.15	5.50	25.58	10.95	52.82	412
1918	" " "	4.05	5.75	25.78	14.52	49.90	433
1916	Randel's Sol. Dry Milk. W. A. Randel & Co.	3.37	8.10	34.45	1.46	52.62	361
1916	Skimilkris. Borden's Cond. Milk Co.	2.90	8.30	35.73	1.93	51.14	365
1909	Trumilk. Merrell-Soule Co.	3.78	6.00	25.65	47.36	37.21	498

The legal restrictions as to the sale of skimmed milk as such doubtless also contributed to the development of this method of marketing this valuable, and too often neglected, food.

Trumilk, essentially a dried whole milk, we believe is no longer on the market. *Klim,* manufactured by the same firm, *Krystalak, Lactora, Randel's Soluble Dry Milk* and *Skimilkris,* are all skimmed milk powders of quite similar composition.

Mammala is a dried milk from which about one-half of the milk fat has been removed and a corresponding percentage of milk sugar added. It is offered especially for the feeding of babies, invalids and convalescents.

In these days of high prices there is every reason to recommend such foods as these milk powders, especially as their production represents a distinct conservation of our food resources. Too often fat is considered the only valuable constituent of milk, the value of its protein being almost entirely overlooked. At the present time skimmed milk is one of our cheapest sources of protein.

HEBE.

This is an evaporated skimmed milk to which about 6 per cent. of cocoanut oil has been added. Cocoanut fat is not an adequate substitute for milk fat in a food for children or invalids, and no such claim is made or implied for this preparation. It should be a satisfactory food for the purposes stated on the label, namely:

"for coffee and cereals, baking and cooking." Our analysis, made in 1918, follows:

Water	74.51
Ash	1.58
Protein (N x 6.38)	6.38
Fat	8.18
Lactose	9.35
Calories per 100 gms	137

SUGAR-FREE MILKS.

These preparations have a distinct value in diets where carbohydrates are restricted, as in the case of those suffering from diabètes. We have examined two brands, *Dr. Bouma's*, sold by Gustav Muller & Co., New York, and *Whiting's*, sold by D. Whiting and Sons, Boston. Our analyses follow:

	Bouma	*Whiting.*	
	1913	1913	1919
Water	91.8	86.4	83.3
Ash	0.5	0.7	0.8
Protein (N x 6.38)	2.4	5.7	6.4
Nitrogen-free extract	0.0	Tr.	0.2
Fat	5.3	7.2	9.3
Calories per 100 gms	57	88	110

These products are both true to name and contain mere traces of carbohydrates. The *Whiting* brand, however, is the more concentrated of the two, and our analysis of this brand just completed shows considerably more nutriment than was shown by the same brand in 1913.

Connecticut Agricultural Experiment Station

NEW HAVEN, CONN.

Report of the Botanist

For Years 1917-18

G. P. CLINTON, Sc.D.

(Being Bulletin 214, Connecticut Agricultural Experiment Station)

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CO-OPERATIVE POTATO SPRAYING IN 1917.

G. P. Clinton, Botanist.
L. F. Harvey, Farm Bureau Agent.

Nature of Experiments.

This is the second report on co-operative potato spraying, the first having been made by G. P. Clinton and F. E. Rogers, former County Agent of New Haven County, in the Station's Report for 1916, pp. 355–64. The experiments for 1917 were confined to home-made 4–4–50 Bordeaux, this having proven most practical in the previous experiments, and were merely to determine how efficient spraying was under ordinary farm conditions, and, as it turned out, in a year when blight was not especially troublesome. It was planned to give four to six treatments according to weather conditions and with the equipment at hand. The conditions varied so at the different farms where the experiments were conducted that the details are given under each. Thanks are due the owners for their aid in conducting the experiments, which were made at the following places: Arthur D. Clark's, Charles R. Treat's, and S. D. Woodruff & Sons', Orange; S. A. Smith & Son's, Clintonville; Whittemore's Estate, W. M. Shepardson, Manager, Middlebury.

Experiments were also planned at the farm of Robert Treat, Woodmont. Two sprayings were made by Mr. Treat, one about the 1st of July and the second on July 20th, but further treatments were omitted because of the dying condition of a large part of the field the last of that month. This unusual trouble may have been partly due to lice, but probably drought and unbalanced fertilization, factors that figured so prominently in the wilt and prematuring of fields in this State in 1918, were as much to blame. No yields were taken from this field, as evidently the two sprayings had not been of value under these conditions.

The first sprayings were made early in July at all the places before any signs of the blight had appeared. In fact the very first blight found that year in the State was on July 24th at South Manchester, and was not found in any of the sprayed fields until considerably later. Blight caused no very evident harm except in the Middlebury field, which was quite wet in spots. At the

Treat farm the vines were all dead from sun scorch before any signs of blight appeared. Their premature death during August was due to very hot weather on the last few days of July and the first of August. The damage caused by this hot weather made unnecessary the sprayings planned for the last of August, except at the Whittemore estate.

The results of spraying were determined by yields taken of 100 foot lengths, in comparable rows of the different plots, and the yields per acre figured from these by the method indicated in the previous report. No figures for cost of labor or supplies were kept, but those given in the 1916 report apply fairly well. The details of treatments, observations and results at each place follow.

At Arthur D. Clark's Farm.

Mr. Clark's field of three or four acres was very conveniently situated to the barn with water supply, etc. The field of Green Mountains was in fine shape when the spraying was started and was on high ground, somewhat rolling, with variable soil conditions, especially as regards retention of moisture. A one-horse Iron Age power sprayer, with single nozzles provided with strainer attachments for each of four rows, was used. The four sprayings were made as follows: 1st, July 6th; 2nd, July 16th; 3rd, July 27th; 4th, Aug. 13th. The sprayed plots were gone over twice, in opposite directions, at each spraying. In the first two treatments arsenate of lead paste, rate of 4 lbs. per 50 gals., was used in the Bordeaux for potato bugs, and the checks were sprayed at the same time and rate with the paste in water.

The plots were as follows:

Rows 1 to 4. Check.
Rows 5 to 36. Bordeaux (twice over).
Rows 37 to 40. Check.
Rows 41 on. Sprayed as desired by Mr. Clark.

The first twelve rows were planted with Maine grown seed, and the remainder with home-grown (one season) of same variety. On July 27th the vines of the Maine grown seed were distinctly larger and so more difficult to coat thoroughly with the spray than the home grown. Also on this date the effect of the poorer and more leachy soil in certain parts of the field began to show in the prematuring and yellowing of the vines, despite the fairly

good fertilizer applied. At the time of the fourth spraying, August 13th, some of the vines were dying prematurely, especially on the poorer part of the field, and more of those from home grown than from the Maine grown seed. There was no blight present. The hot weather of the last of July with resultant drought conditions in the leachier soil was entirely responsible for the trouble. There was little difference between sprayed and unsprayed plots. On Aug. 28th, one fourth of the vines were dead due to drought, with sprayed plots a little better than unsprayed. Found the first blight at this time on the low spot in the field but it appeared too late to cause much damage. Two rows of the Maine grown seed, from which Mr. Clark had cut six inches off the tops about two weeks before, were greener than the other vines in the rows on either side.

The potatoes were dug October 15th. The results of the yields are given in Table 1. From this it can be seen: 1st, That the Maine grown seed yielded better than the home grown, as was indicated by the appearance of the vines earlier; 2nd, That in each case the sprayed plots yielded better than the corresponding unsprayed plots; 3rd, That the average increase was about 18 bushels per acre, enough to slightly more than pay the cost of the spraying at the current price of potatoes per bushel (probably $15.00 clear profit); 4th, That the greatest difference between the sprayed and unsprayed plots was shown on the wet end of the field where the blight had been found on the foliage doing some damage.

At Charles R. Treat's Farm.

Green Mountain potatoes were planted here on two or three acres of sod land, and had the usual good fertilization and cultivation given by Mr. Treat. The sprayings were made with a one-horse 4-row Iron Age power sprayer with single nozzles provided with strainers. Part of the field was gone over once at each spraying with Bordeaux and part twice, the second time in the opposite direction. The sprayings were made on the following dates: 1st, July 2nd; 2nd, July 16th; 3rd, July 27th; 4th, Aug. 13th. In the first two treatments, arsenate of lead at the rate of 4 lbs. per 50 gals. was used in the Bordeaux, and in water for the checks.

The plots were as follows:

Rows 1 to 5. Check.

TABLE 1. DATA FOR THE A. D. CLARK FARM, ORANGE.

Treatment.		Feet dug	Row	lbs. 1st.	lbs. 2nd.	lbs. Total.	No. rot.	Rate 1st.	bu. per 2nd.
Check. No Bordeaux......... (1)	Dry end	100	2–3	70.0	17.5	87.5	0	169.4	42.4
Twice over Bordeaux.......... 4 times. (1)	Dry end	100	7–8	72.0	18.5	90.5	0	174.2	44.8
Twice over Bordeaux.......... 4 times. (2)	Dry end	100	34–35	58.0	13.0	71.0	0	140.4	31.4
Check. No Bordeaux......... (2)	Dry end	100	38–39	52.5	17.0	69.5	0	127.1	41.1
Check. No Bordeaux......... (1)	Wet end	100	2–3	84.0	13.0	97.0	25	203.3	31.4
Twice over Bordeaux.......... 4 times. (1)	Wet end	100	8–9	101.5	12.5	114.0	18	245.6	30.3
Totals, Check..................		300	2–3 38–39 2–3	206.5	47.5	254.0	25	166.6	38.3
Totals, Bordeaux................		300	7–8 34–35 8–9	231.5	44.0	275.5	18	186.7	35.5

(1) Maine grown seed. (2) Home grown seed.

Rows 6 to 20. Bordeaux, once over each treatment.

Rows 21 to 81. Bordeaux, twice over each treatment.

The field was low, quite level and fairly uniform in character On July 27th the vines were in fine shape except a small spot in the twice over Bordeaux plot, where lice had caused some injury On Aug. 13th, however, they showed one-half the foliage dead, so the treatment on this date did little good. By Aug. 28th they were four-fifths dead. No difference showed in favor of the sprayed plots, and no blight was found at any time in the field There is no doubt that the vines were so severely injured by the three or four days of unusually hot weather the last of July and Aug. 1st, resulting in premature death during August, that the spraying had not yet begun to produce the beneficial effects that usually appear from the last of August on. The vines here suffered more from this hot spell than at any of the other farms. One row next the corn, which shaded it somewhat, kept green longer than the others.

TABLE 2. DATA FROM THE C. R. TREAT FARM, ORANGE.

Treatment.	Feet dug	Row	lbs. 1st.	lbs. 2nd.	lbs. Total.	No. rot.	Rate 1st.	bu. per 2nd.	acre Tota
:. No Bordeaux............ (1)	100	2–3	65.5	16.0	81.5	0	158.5	38.7	197.
over Bordeaux 4 times....... (1)	100	7–8	56.5	15.5	72.0	0	136.7	37.5	174.
over Bordeaux 4 times...... (1)	100	21–22	53.5	13.5	67.0	0	129.4	32.7	162.
. No Bordeaux............ (2)	100	3–4	73.0	13.5	86.5	0	176.6	32.7	209.
over, Bordeaux 4 times....... (2)	100	8–9	67.5	16.5	84.0	0	163.4	39.9	203.
over Bordeaux 4 times...... (2)	100	21–22	67.5	10.5	78.0	0	163.4	25.4	188.
, Check....................	200	2–3 3–4	138.5	29.5	168.0	0	167.6	35.7	203.
, Bordeaux once over.......	200	7–8 8–9	124.0	32.0	156.0	0	150.0	38.7	188.
, Bordeaux twice over......	200	21–22 21–22	121.0	24.0	145.0	0	146.4	29.0	175.

West side, south end of rows. (2) West side, center of rows.

The potatoes were dug on Sept. 27th. The results of the yields are given in Table 2. From the results and the observations made, it is evident: 1st, That the spraying did no good; 2nd, This was due to the premature death of the vines resulting from the sudden hot spell in July and August, before any blight got started; 3rd, The trampling of the ground and vines in spraying resulted in a decreased yield, shown most markedly in the twice over Bordeaux plots. Ordinarily where the vines are not killed prematurely, this slight injury due to trampling is overcome later in the season and additional gain made through the greater vigor and longevity of the sprayed vines.

At S. D. Woodruff & Sons' Farm.

As at the other places the potatoes were Green Mountains, with the fertilization and cultivation as ordinarily given by the owner. The field was similar to that at the Clark farm, being somewhat

lower and perhaps less variable in soil conditions, though none the less rolling. The planting, made with a planter, showed quite a few misses giving an uneven stand in the rows in scattered places. The one-horse Iron Age power sprayer used here, while of the four-rowed type with a single nozzle to a row, had a somewhat stronger pump, that gave a more even distribution of spray material. The sprayings were made on the following dates: 1st, July 6th; 2nd, July 16th; 3rd, July 27th. The fourth spraying planned for Aug. 13th was omitted because the machine was not available. Poison for bugs was used in same way as at the other farms.

The plots were as follows:

Rows 1 to 16. Check.

Rows 17 to 56. Bordeaux, twice over each time in opposite directions.

Rows 57 to 60. Check.

Row 61 on. Sprayed as desired by owner.

On August 13th the field was somewhat weedy, and by Aug. 28th, the weeds were so large and abundant as to cause more or less damage. On neither of those dates did the vines show as much injury from the hot weather of July as did those at either the Clark or the Treat farm. This was probably due to better soil conditions for retaining moisture. Blight had not appeared in the field up to the last of August. Little difference was seen between the sprayed and unsprayed parts of the field.

The potatoes were dug on Sept. 25th. The results are shown in Table 3. The conclusions are as follows: 1st, That the sprayed plots gave a very slight increase over the unsprayed; 2nd, That there was more variability in yield between the two checks than there was between them and the Bordeaux plots, probably due to uneveness of stand and soil conditions, though we tried to avoid such in selecting the spots that were dug; 3rd, The few sprayings given, the weediness of the field, the absence of blight, etc., made conditions such that very favorable results from the spraying could not be expected.

At S. A. Smith & Son's Farm.

The Green Mountain potatoes at this place were sprayed the first time with a hand-power barrel pump placed on a wagon to which was attached a stationary nozzle arrangement for spray-

TABLE 3. DATA FROM THE S. D. WOODRUFF & SONS' FARM, ORANGE.

Treatment.	Feet dug	Row	lbs. 1st.	lbs. 2nd.	lbs. Total.	No. rot.	Rate 1st.	bu. per 2nd.	acr Tot
k. No Bordeaux (1)	100	14	81.5	15.5	97.0	8	197.2	37.5	234
e over Bordeaux 3 times (1)	100	19	72.0	15.5	87.5	0	174.2	37.5	211
k. No Bordeaux (2)	100	58-59	64.0	9.5	73.5	6	154.9	23.0	177
e over Bordeaux 3 times (2)	100	51, 55	75.0	13.0	88.0	5	181.5	31.5	213
ls, Check	200	14 58-59	145.5	25.0	170.5	14	176.1	30.3	206
ls, Bordeaux	200	19 51, 55	147.0	28.5	175.5	5	177.9	34.5	212

) Rows next road. (2) Rows center of field.

ing four rows, each from a single nozzle. This worked so poorly that part of the rows were gone over three times to thoroughly coat them. The next two sprayings were made by hand with two lines of hose and were done more thoroughly than at any other place. The first two sprayings contained powdered lead arsenate at rate of 2 lbs. per 50 gals. Bordeaux, for the bugs, and the checks received similar amounts in water. The sprayings were made on following dates: 1st, July 6th; 2nd, July 17th; 3rd, Aug. 6th. The abundance of weeds made it undesirable to give the fourth spraying.

The plots were as follows:

Rows 1 to 4. Check.

Rows 5 to 48. Bordeaux, thorough hand treatments.

Rows 49 to 55. Check.

On August 6th the field was becoming very weedy, and on Aug. 30th the weeds were so large and numerous as to seriously interfere with the crop, except in six rows where they had been pulled on Aug. 6th. The vines suffered little from the July hot spell and on Aug. 30th were greener than at any of the Orange farms. The first check rows showed little blight on Aug. 30th; however, the second check rows, in a lower damper part of the field, showed more. The spray at this time had mostly washed off the vines.

TABLE 4. DATA FROM S. A. SMITH & SON'S FARM, CLINTONVILLI

Treatment	Feet dug	Row	lbs. 1st.	lbs. 2nd.	lbs. Total	No. rot	Rate 1st.	bu. pe 2nd.
Check. No Bordeaux............ (1)	100	2–3	64.5	13.5	78.0	5	156.1	32.7
Twice over Bordeaux 3 times...... (1)	100	5–6	81.0	15.5	96.5	3	196.0	37.ε
Twice over Bordeaux 3 times...... (2)	100	43–44	48.5	15.5	64.0	0	117.4	37.ξ
Check. No Bordeaux............ (2)	100	50–51	53.0	22.0	75.0	2	128.3	53.2
Totals, Check....................	200	2–3 50–51	117.5	35.5	153.0	7	142.2	42.9
Totals, Bordeaux................	200	5–6 43–44	129.5	31.0	160.5	3	156.7	37.ξ

(1) Weeded. (2) Not weeded.

The potatoes were dug October 8th. The results are given i Table 4. From this experiment it is seen: 1st, That the spraye vines gave a little better yield than the unsprayed, about enoug to pay for the cost of the treatments; 2nd, That the part of th field kept thoroughly weeded showed greater difference in favo of the spraying and also in favor of weeding. We do not know wh Bordeaux plot 2 gave a smaller yield than check plot 2, unless th former was from home grown and the latter from Maine grow seed which was used in this end of the field.

At Whittemore's Estate Farm, Middlebury.

This field of several acres of Green Mountains was on a hill sid and part of one end was quite moist even in dry weather, so tha in the early season the potatoes were nearly smothered out there It had been in sod the previous year, top dressed in the spring and when plowed under had been so very liberally fertilized tha the soil was in unusually good condition. The vines were spraye with the large two-horse, 4-row Iron Age power sprayer that ha three nozzles to a row, one above and on either side. The powe was sufficient to give a very misty spray that with slow drivin coated the vines in fair shape with the one spraying that wa given at each treatment. Arsenate of lead was used in the firs two treatments and on the check for bugs. The sprayings wer

ıde on the following dates: 1st, July 3rd; 2nd, July 11th; 3rd, ly 19th; 4th, July 30th; 5th, Aug. 14th; 6th, Aug. 27th; 7th, pt. 3rd.

The plots were as follows:

Rows 1 to 12. Bordeaux, once over.

Rows 13 to 16. Check.

Rows 17 on. Bordeaux, once over.

The hot weather did not hurt this field and it remained green ıch longer than any of the others. In fact at the time of digging, ;t. 16th, some of the vines were still green! One of the largest ls, the vine of which was unusually luxuriant, yielded seven ·ge potatoes and two small ones, a total weight of five and a half unds. The tubers on the whole were rather large, one of the ·gest weighing eighteen and a half ounces. The large yield and ·ge size of tubers were due to the good fertilization and the tended growth period of vines resulting from the spraying. ight eventually appeared in September and caused death of e foliage and rot of the tubers especially in the wet area, and to a ;s extent in the unsprayed drier part of the field.

The yields are shown in Table 5. An examination of this shows: t, That the spraying very considerably increased the yield in

5. DATA FROM THE WHITTEMORE ESTATE FARM, W. M. SHEPARDSON, MANAGER.

Treatment.	Feet dug	Row	lbs. 1st.	lbs. 2nd.	lbs. Total.	No. rot.	Rate 1st.	bu. per 2nd.	acre Total
ɘr Bordeaux 7 times....	100	10–11	124.5	11.5	136.0	3	301.3	27.8	329.1
No Bordeaux.........	100	14–15	95.5	7.5	103.0	60	231.1	18.2	249.3
ɘr Bordeaux 7 times....	100	18–19	143.5	8.0	151.5	11	347.2	19.4	366.6
ɘr Bordeaux 7 times.... (1)	100	10–11	85.5	8.0	93.5	106	206.9	19.4	226.3
No Bordeaux......... (1)	100	14–15	22.5	6.0	28.5	257	54.5	14.5	69.0
ɘr Bordeaux 7 times.... (1)	100	18–19	34.0	6.0	40.0	253	82.3	14.5	96.8
Check.................	200	14–15 14–15	118.0	13.5	131.5	317	142.8	16.3	159.1
Bordeaux............	400	(2) 10–11 (2) 18–19	387.5	33.5	421.0	373	234.4	20.3	254.7

each case over the adjacent unsprayed rows; 2nd, This increase averaged 95 bushels per acre; 3rd, The increased yield was in part due to the prolonged life of the vines, and in part to preventing rot of the tubers; 4th, The spraying did not prevent rot in the very wet part of the field, where considerably over half of the tubers rotted though it helped somewhat even there.

General Conclusions.

These were potato spraying experiments, chiefly with horse-power sprayers, carried on under the ordinary operations at five different farms. The hot weather, of three days the last of July and the 1st of August, seriously interfered with the results by prematurely killing or injuring the vines in August in two of the fields, and to a small extent in two more. This rendered unnecessary the last one or two sprayings that had been planned. Blight caused no conspicuous injury except in one field. The spraying harmed rather than helped in one field, due to trampling of vines in spraying and the premature death of the vines from drought before the effect of spraying showed; two fields were benefitted about enough to pay for the cost of spraying; one field gave an increase about (18 bushels) slightly above the cost; one field, where blight was prevented, gave an increase (95 bushels) very greatly in excess of the cost of spraying.

FERTILIZER EXPERIMENTS WITH POTATOES.

E. H. Jenkins, Director.
G. P. Clinton, Botanist.

The following is an account of observations on the yields of potatoes as affected by different fertilizers, especially as regards potash, conducted by Mr. W. M. Shepardson, Middlebury, Conn., the writers making the weighings at digging time, and by Mr. F. C. Davis, of Somers.

The first lot, northwest of Mr. Bristol's house, was in turf the previous spring and had not been cultivated for many years. In 1917 it was plowed, dressed with 25 loads of manure to the acre, and the fertilizers named were put in the drill at the rate of 1000 pounds per acre. The rows were 2¾ feet apart. The Green Mountain potatoes were planted by machine on June 9th. The stand obtained was quite uniform.

The potatoes were dug on Oct. 19th, and the crop on the two central rows of each plot, 100 feet long, was weighed and sorted into firsts and seconds. These tubers were obviously scabby where ashes were used, and more scabby where 2000 pounds of ashes were used than where half that amount was applied.

The weights in lbs. of the potatoes on the 2 rows were as follows:

Fertilizers.	lbs. Firsts.	lbs. Seconds.	lbs. Total.	*Est. Total Bu. per acre
Essex 4–8–4 (1916 stock)	112½	40	152½	184.5
" 4–10–0	122½	37½	160	193.6
" 4–10–0, 1000 lbs. ashes per acre	132½	37½	170	205.7
" 4–10–0, 2000 " " " "	157½	22½	180	217.8
Buffalo 2–9–4 (Templeton)	117½	30	147½	178.5
Essex 4–8–4 (1916)	127½	35	162½	196.6
Bowker 3½–9–4 (1916)	122½	42½	165	199.7
Buffalo 2–9–4 (Templeton)	117½	35	152½	184.5
Buffalo 2–9–4 (Outside rows)	125	27½	152½	184.5

*Estimated on basis of an acre field 16 by 10 rods, rows running lengthwise of field, and 3 feet apart.

The most noticeable things are that the duplicates with Essex and Buffalo in different parts of field gave rather uniform results indicating uniformity in the soil of the field.

The addition of ashes to the Essex 4–10–0 increased the yield and 2000 lbs. increased it more than 1000 lbs., particularly in the No.

1 potatoes. The ashes however induced scab, though not enough to *seriously* damage market quality.

On a neighboring field planted to Green Mountain on June 8th in rows 2 ft. 10 in. apart, 2 rows each 150 feet long were dug in each plot. 1000 lbs. of the fertilizers were used and on some plots varying amounts of wood ashes were added.

	Firsts. lbs.	Seconds. lbs.	Totals. lbs.	*Est. of Total bu. per acre.
Essex 4–8–4	180	75	255	205.7
" 4–10–0, no ashes,	200	55	255	205.7
" " " " 1000 lbs. ash	165	70	235	189.6
" " " " 2000 " "	230	80	310	250.1
" " " " 3000 " "	250	60	310	250.1

*Estimated on basis of an acre field 16 by 10 rods, rows running lengthwise of field, and 3 feet apart.

Here 1000 lbs. ashes had no apparent effect, 2000 and 3000 lbs. ashes increased yield to same amount. Scab was more abundant where ashes were used than on plots where not used, but there was not much difference due to the different amounts used.

In neither field did the Essex 4–8–4, with potash, give a better yield than the 4–10–0 without it. However, in both fields the addition of a ton or more of wood ashes to the Essex 4–10–0 materially increased the yield, due either to the greater amount of potash or to the lime they contained.

Mr. F. C. Davis, of Somers, reports in 1918 more favorable returns from potash, where he used it alternating on seven strips of twelve rows each, in a 3–8–3 formula in comparison with a 4–10–0. The land was a gravelly loam in corn the previous year. The fertilizers were applied in three doses as follows: 800 lbs. before the first harrowing, working it in thoroughly with the stalks and plowing under, 400 in the planter and 600 at the time of the second cultivation.

There was no difference between the strips during the growing season until the last ten days, the potash strips remaining alive that much longer. The difference in yield was about 50 bushels per acre in favor of the potash fertilizer. This at the price the potatoes were sold was a gain of $75 per acre or, deducting the extra cost of this fertilizer, a net gain of $64.

INSPECTION OF PHAENOGAMIC HERBARIA FOR RUSTS ON RIBES SPS.

G. P. Clinton, Botanist.

Not infrequently one can find specimens of certain fungi easier by looking through a collection of flowering plants in an herbarium than by going out doors and looking for them on the living hosts. This is true of certain smuts and rusts and especially so if the desired hosts do not occur in one's vicinity but are found in a large phaenogamic herbarium near by. Thinking that such a search through a number of herbaria perhaps might throw light on the early occurrence of *Cronartium ribicola* in this country, the writer in 1916 and 1917 carefully looked over the specimens of *Ribes*, including *Grossularia*, in the following eastern herbaria: (1) Conn. Agr. Sta. Herb., (2) Conn. Bot. Club Herb., (3) Yale Univ. Herb., (4) N. Y. Bot Gard. Herb., (5) Columbia Univ. Herb., (6) Grey Herb., (7) N. E. Bot. Club. Herb., (8) U. S. Nat. Herb. Requests were also sent to several central and western herbaria that leaves containing suspicious rust specimens be sent the writer and several such were received from the following: (9) Mo. Bot. Gard. Herb., sent by Greenman, (10) Univ. of Wash. Herb., by Hotson, (11) Univ of Calif. Herb., by Jepson. No rusts, however, were found on specimens sent from the last two herbaria.

While this investigation did not throw any light on the occurence of *Cronartium ribicola* in this country, except what might be considered negative evidence, still information was obtained of its existence elsewhere and of the distribution, hosts, etc., of three other rusts in this country. We have thought it worth while to record here this data, together with some general remarks on the same. The figures in parentheses, following the name of the collector with each collection, refer to the herbarium, as numbered in the preceding paragraph, in which the *Ribes* were examined. Most of these fragmentary specimens containing the enumerated rusts are now in the herbarium of the Conn. Agr. Exp. Station.

Besides these rusts several other fungi were observed but no particular attention was paid to them. They included the following: *Gleosporium Ribis* (Lib.) Mont. & Desm., on *Ribes Lobbii*, Klickitat Co., Wash., 7 Au. 1897, Suksdorf (6); on *Ribes nigrum*, Mt. Lancaster, Coos Co., N. H., 25 Au. 1913, Pease (7). *Septoria*

aurea destruens E & E., on *Ribes aureum*, Mobridge, S. Dak., 28 Jl. 1907, Bailey (8).

Aecidium Grossulariae (P.) *Schum.*

This fungus has now been proven by infection experiments to be the I stage of *Puccinia Grossulariae* (Schum.) Lag. with its II and III stages on *Carex* sps. Whether or not all of the aecia on the various species of *Ribes* scattered over the country are the same thing can only be determined by further inoculation tests. Arthur (Journ. Myc. **8**: 53. 1902.) has described another *Puccinia, P. albiperidia*, with its II and III stages on *Carex* and its I stage on *Ribes* sps., distinguished by its white or nearly white aecia (*Aecidium albiperidium*). The same author (Mycologia **4**: 14. 1912.) thinks that *Uromyces uniporulus* Kern also has its aecia on *Ribes*. We have however grouped all the specimens reported here under *Aecidium Grossulariae* as they showed no evident difference. This rust occurs very commonly on herbarium material and in the immature stage resembles somewhat the II stage of *Cronartium ribicola*. However, one soon learns to distinguish it in this stage with the hand lens through the larger size of the aecia and the presence of pycnia. This rust was collected on eleven different hosts as follows:

On *Ribes americanum* (*R. floridum*):—New Haven, Ct., 27 My. 1879, Livingston (3); Oxford, Ct., 23 Je. 1901, Harger (2); Bellevue, Wisc., 27 My. 1882, Schnelle (6); Norway, Neb., 22 Je. 1893, Rydberg (6, 8).

On *Ribes bracteosum*:—Chilliwach Valley, B. C., 8 Jl. 1901, Macoun (8).

On *Ribes* (*Grossularia*) *Cynosbati*:—Jackson, N. H., 29 Jl. 1876, Allen (1); Orono, Me., 25 Au. 1913, Pease (7); Northumberland, N. H., 31 Jl. 1909, Pease (7); Manchester, Vt., 30 Je. 1898, Day (7); Colebrook, N. H., 13 Jl. 1907, Pease (7); Kingston, Ont., 5 Je. 1902, Fowler (8); New Harpersfield, N. Y., 8 Je. 1906, Toppin (8).

On *Ribes* (*Grossularia*) *divaricatum*:—Yellowstone, Neb., Au. 1854, Hayden (9); Chehalis Co., Wash., 10 My. 1897, (4).

On *Ribes* (*Grossularia*) *gracile*:—Near Minneapolis, Minn., My. 1891, Aiton (3).

On *Ribes* (*Grossularia*) *hirtellum*:—Berlin, Mass., 13 Je. 1915, Winslow (7); Clinton Co., Ia., 23 Ap. 1878, Butler (1); Foxcroft,

Me., 25 Je.,1894, Fernald (7); Dead River, Me., 19 Au. 1896, Fernald & Strong (7).

On *Ribes lacustre*:—Sherburne, Vt., 18 Je. 1899, (4); Pittsburg, N. H., 5 Jl. 1907, Pease (7).

On *Ribes prostratum*:—Mt. Washington, N. H., 24 Je. 1893, Greenman (9), 24 Je. 1898, Williams (7); Straits Belle Isle, Lab., 1 Au. 1910, Fernald & Wiegand (6); Orono, Me., 1 Jl. 1892, Fernald (7); Cumberland, Me., 29 My. 1902, Chamberlain (7); Mt. Mansfield, Vt. 2 Jl. 1897, Williams (7); Oakham, Mass., 12 My. 1912, Fernald (7); Adams, Mass., 4 Je. 1898, Churchill (7).

On *Ribes* (*Grossularia*) *rotundifolium*:—Ames, Ia., Hitchcock (9); Ia., 1871, (9); Clinton Co., Ia., 22 Ap. 1878, Butler (1).

On *Ribes* (*Grossularia*) *saximontanum*:—Platte Canyon, Natrona Co., Wy., 7 Je. 1901, Godding (9).

On *Ribes* (*Grossularia*) *setosum*:—Buffalo, Wy., Jl. 1900, Tweedy (3); Bozeman, Mont., 18 My. 1901, Jones (8).

Coleosporium ribicola (C. & E.) Arth.

This is a western rust of which the aecial stage apparently is not yet known. It is probably some Peridermium on the leaves of *Pinus* sps. The uredinial stage was first described in 1878 (Grev. **6**: 86.) by Cooke & Ellis from the Rocky Mts., on *Ribes* sp. Arthur (N. A. Flora **7**: 86. 1907) who placed it under the genus *Coleosporium* and described the telial stage, gives Rocky Mountains (*Colorado*) and *Ribes* (*leptanthum*) as the type locality and host. In 1885 Peck (Bull. Torr. Bot. Club **12**: 36.) again described this species on *Ribes* from New Mexico under the name *Uredo Jonesii*. It is interesting to note here that at least 24 years before Cooke & Ellis first described the fungus it was unknowingly collected by Bigelow (Botanist, Whipple Exp. R. R. Route Miss. R. to Pacific Ocean, Fort Smith to the Rio Grande in 1853–4) on *Ribes leptanthum* as shown by specimens taken from this host in the Gray Herbarium. Arthur in his monograph cites as hosts five species of *Ribes* from eight states. We list here at least eight hosts from ten different localities, as follows:

On *Ribes aureum*:—Nogal Canyon, White Mts., New Mex., 17 Au. 1901, Wooton (II, 4), (III, 8).

On *Ribes* (*Grossularia*) *hirtellum*:—Black Tail Deer Creek, Yellowstone Park, III, Au. 1884, Tweedy (3).

On *Ribes lacustre* (*R. echinatum*):—Cascade Mts., Wash., II, 10 Au. 1893, Allen (4).

On *Ribes* (*Grossularia*) *leptanthum*:—Fort Smith to the Rio Grande, Whipple Exp., III, 1853–4, Bigelow (6).

On *Ribes montigenum*:—Sandia Mts., Sandoval Co., New Mex., III, 3 Au. 1910, Wooton (8); Sandia Mts., Balsam Park, New Mex., II, 17 Ap. 1914, Miss Ellis (4).

On *Ribes* (*Grossularia*) *pinetorum*:—Chloride, New Mex., III, 12 O. 1909, Goldman (8).

On *Ribes triste* (*R. rubrum*):—Yakon Valley, 40 Mile River, II, 17 Je. 1902, Collier (8).

On *Ribes Wolfii*:—Sandia Mts., Balsam Park, New Mex., III, 28 My. 1914, Miss Ellis (4).

On *Ribes* (*Grossularia*) sp.:—Calif., III, 11 S. 1909, Rusby (4).

Cronartium ribicola F. deW.

The search through various herbaria for this fungus was to learn, if possible, whether it occurred in the New England states earlier than the first reported collections made in 1914, and whether it was native in Colorado on *Ribes longiflorum* as indicated by the collections of Bethel. Nothing was learned along either of these lines. The western *Cronartium* in its II stage was first collected on *Ribes longiflorum* by Bartholomew in Stockton, Kans., Aug. 22, 1892, but has never appeared there since. During the last ten years Bethel has collected it a number of times on the same host, in both stages, at Boulder, Denver, and also other places in Colorado where it appears to be native. Recent experiments by government investigators have shown these collections to be distinct from our eastern introduced species altho *Ribes longiflorum* is considered by some as a synonym of *Ribes odoratum*, a common host in New England for *Cronartium ribicola*. In our search of herbaria, however, we did not find any Cronartium on *Ribes longiflorum*, though we did secure *Cronartium ribicola* on three specimens, two from Europe and one from Asia, as follows:

On *Ribes aureum* (*R. leiobotrys*):—Cult. plants in Berlin, Germany, II, III, 5 My. 1893, Koehne (6).

On *Ribes* (*Grossularia*) *divaricatum* (*R. irrigum*):—Cult. plants in Berlin, Germany, 9 Au. 1895, Koehne (6).

On *Ribes* sp:—C. China, W. Hupeh, My. 1900, Wilson, no. 515, (4).

Puccinia Ribis D. C.

This fungus is found in Europe and America, but is apparently not very common here, at least the writer has never collected it in the field. It seems to have a northern distribution and has been reported from New York by Peck, Wisconsin by Davis, Minnesota by Hollway, and probably from other states, and was found on several hosts, but not on the variety reported here. Peck describes it as a new species, *Puccinia pulchella* in 1873. There is only the telial stage in this rust.

On *Ribes triste* var. *albinervium*:—Van Buren, Me., 24 Jl. 1893, Fernald (7).

INFECTION EXPERIMENTS OF PINUS STROBUS WITH CRONARTIUM RIBICOLA.*

G. P. Clinton, Botanist.
Florence A. McCormick, Scientific Assistant.

HISTORICAL CONSIDERATION.

Introduction of Blister Rust in Connecticut, etc. In an article dealing with heterœceous rusts found in Connecticut, published by the Station Botanist (**1** p. 394) in his Report for 1907, the statement was made that the blister rust was "liable to be introduced on white pine imported from Europe". In April, 1909, Mr. F. A. Metzger, a forester employed by Mr. C. F. Street at Wilton to set out a plantation of 10,000 three year old white pine seedlings imported through the State Forester from Germany, found fifty to

*In order that the reader may gain at the start a fair idea of the fungus discussed here, a brief outline of its life-history follows: White Pine Blister Rust is the common name for the first or I stage of a rust imported accidentally into America on seedling white pines from Europe. The rust enters the pines through the pores, or stomata, of the needles in the fall. Usually within a year or two after infection, during late summer and fall, lemon-yellow drops containing minute spore-like bodies called pycniospores, ooze out from yellowish (but eventually brownish) areas on the bark, forming the O or pycnial stage of the fungus. The use of these so-called spores has never been determined. The next spring (the last of April to the middle of June) after the appearance of the pycnia, the first true spore stage, called the I or aecial stage, appears. This forms small, white, fragile, irregular eruptions on the bark projecting for about a quarter of an inch. They soon break open at the top disclosing an orange-yellow dusty mass of spores, the aecial spores.

The aecial spores are blown by the wind, or possibly carried by insects to the leaves of the alternate hosts, which comprise the various currants and gooseberries belonging to the genus *Ribes*. Germinating under favorable conditions of moisture, these spores send their germ tubes through the stomata, chiefly situated on the under side of the leaves, and usually within 7 to 12 days give rise there to the II stage of the fungus, called the uredinial stage. This shows as small roundish pustules, smaller than the head of a pin, that contain the yellow semi-dusty urediniospores. These are washed over the leaf or carried to the leaves of same or other plants and, on germinating and gaining entrance to the tissues, produce similar pustules. Through the summer several generations of these urediniospores may be produced spreading the dis-

one hundred infected with an unknown disease. He brought these to the Station and the trouble was later identified by the botanist (**2** p. 731), who was then absent in Japan, as the white pine blister rust. This was the first definite finding of the blister rust in this state and one of the first in America, as about the same time it was also found on imported seedlings set out in several other New England states and New York. It is quite probable that the disease was brought into Connecticut at an even earlier date, as several plantations from foreign stock had been started in 1907, while nurserymen and others, on whose premises the disease has since been found in two cases, had imported seedlings and trees much earlier. There is also considerable evidence to show that it was brought into some of the other states some years before it was definitely first found in 1909. In New York it was introduced at least before 1906.

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ease more or less widely by this repetition. The black currant is especially susceptible to attack.

From midsummer on, the III or telial stage develops on the *Ribes* leaves often appearing in the same pustules following the II stage. This last stage shows as minute reddish-brown hairs about 1 or 2 mm. long and more or less thickly covering the under surface of the leaves. These hairs are composed of teliospores adhering permanently together. They germinate immediately under favorable moisture conditions and give rise to germ threads bearing very small secondary spores, sporidia, that are blown by the wind to the pine needles, and there gain entrance as already indicated.

Infected seedlings before the I stage appears in the spring are usually detected by their bunched leaves and soft swollen stems. When the fruiting pustules appear they are quite conspicuous and the disease is easily recognized. After these disappear in late June, there remains only the roughened dead bark or a yellowish-green area of invaded smooth bark which will break out the next year, to indicate infection. Once the cambium is killed all around the stem the parts above die. Very young infected seedlings do well to live a year, but those two or three years old may live for several years. On older trees if the infection is at the ends of the twigs the damage is not serious, but once the main trunk becomes invaded the tree is doomed though it may remain in vigorous growth for several years and seem perfectly healthy on casual examination of the foliage.

Elimination of *Ribes* in the vicinity of seed beds, thorough spraying of the beds with Bordeaux after midsummer if grown in an infected region, use of uninfected seedlings only for planting, inspection of plantations from foreign stock for infected pines, destruction of all wild or cultivated *Ribes* in plantations and for 300 yards around the same, are precautionary measures advocated for this state.

Upon positive identification, the botanical and forestry departments, in co-operation with the U. S. Department of Agriculture, inspected during 1909 most of the larger plantations scattered over the state, with the result that the blister rust was found in small amounts in several of them. All of the infected trees found were destroyed. In 1910 most of these plantations were re-inspected and several smaller ones were inspected for the first time. About 645,000 out of the 740,000 imported trees that had been set out, were thus inspected once or twice during the two years. As no trees were found infected in 1910, the inspection was practically discontinued. An account of this work appears in the botanist's report for 1909-10.

In the spring of 1912, Mr. Walden, inspecting an importation of white pine from Holland at one of the local nurseries, found some of the seedlings badly infected, and upon identification as this rust by the botanist (**3** p. 347) Dr. Britton ordered them all destroyed. Since that year importation of white pines from countries where the disease occurs has been prohibited by a quarantine of the U. S. Department of Agriculture.

The first outbreak found in this State on *Ribes* species, the alternative host for the II and III stages of this fungus, was found by the senior writer (**3** p. 348) on a few black currants at the home of Mr. H. B. Birdsey at East Meriden, Conn., in October of 1912. The origin of this infection has never been determined, since infected pines have not been found in this general region, though the rust has usually appeared each year since on these bushes.

Nature of Recent Work. In 1916 the rust having become prominent in certain plantations in northeastern United States and Canada, and especially wide-spread on the *Ribes*, the U. S. Department of Agriculture, and the several interested states, undertook anew methods looking for its control within the infected areas, and quarantine laws have since been passed regulating the shipment of five-needle pines and black currants from these to other parts of the country in order to prevent its introduction into other states. This necessitated further work in Connecticut. The forestry department of this station in co-operation with the United States Department of Agriculture, undertook especially the practical work dealing with inspection and control. The botanical department, while also helping with this phase, took as its special

problem the scientific study of the rust in its various aspects. The work under the direction of the forester has been carried on by funds from the U. S. Department of Agriculture and state appropriations, while that by the botanical department from state appropriations alone. It is the purpose of the latter department eventually to publish an illustrated bulletin covering all its investigations.* The report here deals solely with certain interesting discoveries that have been made relating to the method of infection and early development of the blister rust in the white pine. It can now be definitely stated that infection takes place through the stomata on the needles rather than through the stems or buds as commonly supposed. A preliminary note of this work has already been published by the writers (**4** p. 15) in the Report of the Blister Rust Committee for 1918.

Previous Investigations. While Dietrick (**6** p. 287) as early as 1856 reported both the *Peridermium* on white pine and the *Cronartium* on *Ribes* species from Russia, he evidently did not recognize that they had any relationship to each other. Klebahn (**8** p. XLVIII) in 1888 was the first to prove this relation by inoculations, using the aecial spores from the white pine on the leaves of *Ribes nigrum.* Later he and other European investigators, and Spaulding (**19** p. 244) in America, abundantly verified this relation by the inoculation of a great number of *Ribes* species in similar manner.

When we turn to the inoculation of the white pine with the telial stage from the *Ribes,* however, thus completing the evidence of their relationship, we do not find that many investigators have reported experimental evidence. In fact, Klebahn (**10** p. 86) in 1905 seems to have been the first and only European investigator to report such successful inoculations (made in 1903). As early as 1890 he (**9** p. 62) had attempted inoculations but was doubtful as to the results, as the plants used may have already been infected. While there is no doubt that he did infect two white pines under bell jars in the fall of 1903 (**10**), by placing infected leaves of *Ribes nigrum* on a wire net over them, unfortunately

*This report will be published by the writers and Mr. E. M. Stoddard of this department, who has also co-operated largely with the forestry department in its control work. The writers are indebted to him for the photographs and photomicrographs with which this article is illustrated.

he left the pines out doors over winter and did not carefully examine them until the middle of the following June.

It was evidently then too late to determine the very first signs of infection and the manner in which it took place. He noted the yellow spots on the previous year's leaves, of which we shall speak in connection with our own experiments, and found the mycelium of the rust in these spots. He also found that two of the young stems were of a paler color, distorted, and bore at first juvenile leaves instead of the normal fascicles of five leaves. In July spermagonial drops began to appear on the infected branches.

Concerning the manner and place of infection he seemed in doubt, but makes the following remarks: " The fact that localized yellow spots were present in these needles does not necessarily mean that the mycelium arising through infection in the needle has in especially high degree the power to grow forth in the longitudinal direction of the needles, and to penetrate into the branch. Whether the bark of the young branch at the time of the maturity of the sporidia can be pierced by these is likewise doubtful. Therefore it may perhaps be presumed that the fungus can easily penetrate into the branch if the base of the needle is infected. Still another possibility is that the sporidia must infect the young buds for the next year." Klebahn further stated in 1918 (**11**) "For *Peridermium strobi* it is shown that the needles can become infected but not that the mycelium grows from the needles into the bark."

Spaulding (**16** p. 147) in January 1912 published the following brief note concerning his inoculations on white pine: "Greenhouse inoculations have been made upon young *Pinus strobus* with teleutospores secured by inoculation on *Ribes americanum* with aecidiospores borne upon imported trees of *Pinus strobus*. Inoculations thus made in November, 1910, are now beginning to give results. One each of the trees inoculated with wounds and without wounds, is now showing slight swelling such as is so characteristic of the blister rust disease." This statement indicates, as Spaulding has recently told the writers, that the inoculations were on the stems. He also said that none of the infected pines formed the aecial stage, but the pycnia, with exudation of pycniospores, were produced.

From the results of these investigations by Klebahn and Spaulding one is left in doubt whether infection takes place through the

leaves, the buds or the stems, and in what particular manner. Judging from other statements in literature on this subject, the general impression is given that it takes place through the stems. For instance, Fischer, of Switzerland, (**7** p. 435) states: "The aecidiospores infect the *Ribes* leaves upon which first uredo then teleutospores appear; the latter germinate immediately and infect the young twigs of pines." Spaulding (**17** p. 6) says in one of his earlier papers in 1912, concerning infection: "The winter spores are blown from the currant and gooseberry leaves upon which they are produced to various parts of the white pines in the vicinity. There they stick to the bark of the young trees or branches and germinate. The branching threads of the fungus penetrate the inner bark tissues for some distance, but cause no external sign of disease until nearly a year after the time of infection". He makes about the same statements in his excellent bulletin (**15** p. 26) on the "Blister Rust of White Pine" published the year previously, and in 1916 he (**18** p. 14) states: "The teliospores falling upon bark of suitable age on a white pine may in turn germinate, penetrate the bark and grow in the inner layers during the incubation period already mentioned." Metcalf (**14** p. 3) in 1917 makes a similar statement as follows: "The pine blister attacks white pine seedlings or pines of any age that have needle-bearing twigs through which it can enter. The disease spreads from the twig" etc.

McCubbin, also, writes in 1916 (**12** p. 1) "It is believed that the fungus gains entrance by some wound in the twigs or branches, and from the point of entrance it grows rapidly up, down and around the branch in the soft outer bark". In an article written in 1917, however, he (**13** p. 95) questions the branch method of infection as follows:

"Only indefinite references to the method of infection of the pine by *Cronartium ribicola* have appeared in current literature. From these references one gathers the impression that infection takes place through the bark, and probably by way of wounds or abrasions. Having an opportunity for studying a considerable number of pine infections in 1916, some attention was given to this point and records were made of the origins of cankers where such origins could be determined.

"In most cases the determination was not difficult, owing to the fact that in a healthy pine branch the fungus spreads out from the court of entry in a very regular and equal manner, and that its progress is marked by swelling or discoloration or both, or else the cortical tissue is killed in

an equally radial fashion. By taking note of this habit one can readily locate the point of original infection in most cases, especially in the earlier stages.

"Very early in this study it became apparent that the chief mode of infection was by way of leaf fascicles through the so-called short shoots. In these pines, which were all healthy and which grew in situations where they were fairly free from accidents, wound infection played but a very small part.

"According to the tabulated results about 92 per cent. of these young blister cankers originate in leaf-bundle infection. This percentage includes only those cases where the point of origin could be confidently established, but it is highly probable that a large proportion of the number listed as undertermined should also find a place here, and it might not be overstepping the mark to ascribe at least 95 per cent. of these blister cankers to leaf fascicle infection.

"One may consider that the sporidia from the currant leaves are lodged among the bases of the needles and from this position can then attack the short shoot which bears these leaves."

PRESENT INVESTIGATIONS.

First Infections. On October 21, 1916, the senior writer placed infected leaves of *Ribes nigrum,* having the telial stage, over two crocks each containing three two-year old seedlings and two crocks each containing six one-year old seedlings of *Pinus strobus.* These were moistened, covered with bell-jars for several days and have been kept in the greenhouse ever since. Nothing suspicious showing during the first month or two, they were not carefully examined thereafter for some time. On June 14, 1917, the writers looked them over critically and in one of the crocks found two of the one year old seedlings showing conspicuous yellow spots which were not seen on the leaves of the other plants. These two seedlings also showed the bark slightly swollen and of a yellowish-green color. On July 14th one of the two year old seedlings, which had shown nothing very suspicious previously, was found to be oozing pycniospores in less than nine months after inoculation. Later a second of these two-year old seedlings died and microscopic sections showed pycnia. Several of the young seedlings were dead by this time, whether from rust or other causes was not determined. At the present writing two of two-year old and one of the one-year old seedlings are still alive, but show no signs of infection. Thus out of 18 plants at least 4 were definitely known to have become infected.

Sections of the needles through the yellow spots mentioned above showed abundance of mycelium which was also found in the swollen stems and because of this it was uncertain whether the infection had taken place originally through the leaves or stem. It was to settle definitely this point that inoculations in the fall of 1917 were again made. These plants were carefully watched from week to week to obtain the first indications of infection. The results obtained were verified and extended by other experiments made in the fall of 1918. Therefore the data given in the following pages are the combined results of infections made during these three years.

Methods of Inoculation.

In Greenhouse: Condition of seedlings. Practically all of the pine seedlings used in the experiments have been grown in crocks usually from three to ten in a crock, and have been kept ever since in the greenhouse of the Experiment Station. Some of these have been grown from seed and others were obtained from our own and a nearby nursery where blister rust has never occurred. No rust either on *Ribes* or white pines has ever been found in the vicinity of the Station. Therefore there is absolute certainty that any infections that have taken place are the results of our inoculations. Most of the seedlings used have been one, two or three years old, since for convenience and ease of infection these have proved most satisfactory. When we speak of one year old seedlings we mean those of less than a year's growth as they varied in age from four to eight months. Similarly by those two and three years old we mean in their second and third year's development. For the most part these plants have made excellent growth. As they have been kept in the greenhouse the year round they have not had the winter rest period of plants growing outdoors, but during late fall and early winter their growth has been noticeably retarded. Of course where infection has taken place in the fall these plants in late winter and early spring have shown the disease far in advance of those plants infected at the same time but kept outdoors through the winter. This forcing of the plants and the disease indoors must be taken into consideration, at least as regards time, when comparing with infections that take place in nature. It is evident from these experiments, however, that the rate of development of the disease is correlated with the vigor and rapidity of the growth of the plant.

Preventive measures. Unless it were desired to keep certain parts of the plant from becoming infected, the inoculation material was placed in and around the moistened plants which were kept covered with a bell jar in subdued light for several days. Where it was aimed to produce infections through definite parts, care was taken to inclose the inoculation material with damp cotton to prevent the sporidia from escaping, or else the inoculated part was left exposed and all the rest of the plant was protected by dry cotton or paper. Plate XXXVII, fig. 3 shows an example of the latter condition where spores had been placed on the young leafy shoots after the rest of the plant had been covered.

Parts inoculated, (a) Stems. The inoculations on the stems were made in two ways: 1st by cutting a slit in the stem and inserting the germinating telial column; 2nd by applying the telial material to the uninjured stem. In both cases the material on the part inoculated was wrapped with moist cotton. The cotton also served to indicate the place of inoculation later on. The stems used, especially on younger seedlings, were quite small (less than a quarter of an inch in diameter and were one or two years old) except in a few cases where the green stem of the present year's growth on larger plants was used.

(b) Buds. By unopened buds we mean the terminal ones and in an entirely dormant condition closely enwrapped with the enveloping brown scarious scales, with no green parts of leaves exposed. By open buds we included those expanded enough to show the developing leaves. In both cases especial care was taken to protect all other parts below from infection by the devices already mentioned.

(c) Leaves. With inoculation of leaves usually no particular effort was made to prevent general infection, since infection of the leaf was determined by the appearance of yellow spots. It was always possible through microscopical sections of these yellow spots to find the particular stoma or stomata through which entrance was gained. There were four different methods used: (1) placing infected leaves on the soil of the crock, or (2) over the plants themselves, or (3) still attached to stems stuck in the soil, and (4) sprinkling water containing telial material over the plants. In some cases attempts were made to inoculate special parts of the leaves as base, centre, or apex, such places being marked by a string tied at the point of inoculation to identify it for later

examination (Pl. XXXVII, fig. 2). Again, leaves of different ages were used, as those young and still growing and others one or two years old. Also the juvenile leaves, such as first appear on the seedlings (Pl XL, fig. 4) or under exceptional conditions on older plants, were inoculated in comparison with the ordinary leaves which develop in fascicles of fives on the plants after the first year.

In Petrie Dishes. Having been successful with the inoculation of *Ribes* leaves in moist Petrie dishes (**4** p. 14) it was thought that this method might be applied to the pine needles, at least so far as showing place and method of entrance of the germinating sporidia. Both juvenile and fascicled leaves were used, the former on short shoots or on the entire seedling and the latter unattached or attached to the stem (Pl. XXXVII, fig. 1). Inoculations made in 1917 showed no apparent infection though the needles were kept in good condition for a month. Possibly the failure here was due to the fact that the leaves were all of the fascicled form and were kept in the diffused light of the laboratory. The next year the experiments were extended to young seedlings and the Petrie dishes this year were kept in the more direct light of the laboratory greenhouse which faces the east and is protected from southern exposure to the sun by a wing of the building.

Under Tent. Another method tried was the inoculation of pines under a tent, to approximate natural methods of infection without danger of spreading the spores. The tent was made of unbleached muslin stretched over a frame about four by eight feet and about six feet high at the ridge. A door on one side made the examination of the plants easy at any time. To this tent two black currant bushes had been transplanted to determine if the *Cronartium* was carried over on bushes infected the previous year. Nothing showing in this respect the currants were artificially inoculated with urediniospores the middle of the summer of 1918. On August 15, after the appearance of the telial stage, a wooden box containing numerous small two year old white pine seedlings was set in the soil under each bush. On October 2, about a dozen plants from each box were transferred in a bunch to crocks in the greenhouse to see if forcing the plants during the winter might have any effect upon the appearance of the disease. On September 28 a white pine about a foot high and at least five years old was also placed under each infected bush.

Out of Doors. In addition to the preceding, three pines about three or four feet high and six to eight years old growing in a sheltered spot on the Station grounds, and three trees, fifteen to twenty feet high and fifteen to twenty years old at the Whittemore estate in Middlebury, Conn., were also inoculated. In the case of the pines at the Whittemore estate there was a possibility of outside infection since *Peridermium strobi* had been found on certain of these trees. At both the Experiment Station and at Middlebury the method used for inoculation was to spray the branch with water and then to inclose it in a double paper bag in the inner one of which were placed loosely or sewed to the paper fresh *Ribes* leaves infected with the telial stage. A variation of this method was to spray the leaves with water containing the germinating teliospores before placing the bag over the branch. The paper bags were left on the branches from two to four weeks and in some cases even longer. Except for the longest periods, living in the bags did not seem to injure the leaves to any appreciable extent. These experiments at both places were carried on in 1917 and again on other branches or trees in 1918. Altogether in the two years nine branches at the Experiment Station and thirty-one at the Whittemore estate were inoculated.

General Results of Inoculation.

Out of Doors. Of the forty branches inoculated at the Experiment Station grounds and at the Whittemore estate twenty were made each year. Despite these many attempts not a single inoculation was successful so far as can be determined at the present time (July 9, 1919). Those made in 1917 were certainly old enough to show some sign of infection if successful. Close watch has been kept for indication of yellow spots on the leaves so characteristic of greenhouse infection, without any evidence of the same. Somewhat suspicious spots have been sectioned for decisive proof of the presence of the mycelium but also without result.

To some this might indicate that in nature infection does not take place through the leaves, but to the writers it is more of an indication that the methods of inoculation were faulty, since there is no evidence of any infection through the young stems or buds which were equally exposed with the needles. The age of the leaves could not have been the limiting factor, since leaves nearly two years old (about their age limit) were abundantly infected on

the young trees in the greenhouse. It is uncertain whether these apparent failures were due to rapid decline of the inoculating material after being placed in the bags, to unfavorable conditions of moisture or temperature, or to some other unknown factor. In our greenhouse experiments we have had great variations in results of inoculations due to conditions which we have not always been able to explain. We speak of these outdoor inoculations as failures since in the greenhouse experiments some sign of infection visible to the eye has always shown within one to six months after the inoculation if successful.

Under Tent. On October 2, at the time of the transference of part of the two year seedlings from the box under the tent to crocks in the greenhouse, no sign of infection was visible on the leaves. On November 8 a single very inconspicuous yellow spot, evident only under the lens, was found on one of the plants in the tent and this on sectioning showed the characteristic mycelial masses. A day or two previous similar spots had been found on four of the plants transferred to the greenhouse.

During the winter the seedlings in the tent showed little evidence of further development of the fungus. For example, on February 24 only a few spots were seen on the leaves. These were scarcely visible to the naked eye, being about one-fourth of a millimeter long, directly over the stomates and not encircling the leaf as yet. In comparison with the spots on the plants transferred to the greenhouse they were very much less developed. On May 24, however, these spots were more numerous and were evident to the naked eye, some of them encircling the leaf while others were scarcely visible. One plant showed fourteen leaves with these spots and the stem had already become invaded. A very large percentage of the plants apparently were infected. Unfortunately a number of the plants had been winter-killed and during June a severe hot period killed most of the remaining ones, only four being alive in July. This greatly interfered with determining just how far advanced these spots on out of door plants would be at this time of the year, but those that were present were not very striking. These experiments would indicate that infection in nature, which takes place in the fall, is very inconspicuous and may entirely escape detection at that time, and that the spots develop rather slowly during the spring, perhaps in cases not becoming conspicuous until the middle of July.

On the other hand the plants that were transferred October 2 to the greenhouse continued to develop, at first slowly during the late fall and early winter. By Novenber 26 at least seven out of the fifteen plants in one crock and all eight plants in the other crock showed inconspicuous spots indicating infection. By January 28 the spots were more conspicuous, in cases six to ten showing on a single plant. At this time the spots were one-sixteenth of an inch long and barely encircling the leaf. In one plant a slight swelling and yellowing of the stem indicated infection there had already taken place. From February 20 to the middle of March *these spots became quite conspicuous*, usually one to four mm. long and entirely encircling the leaf. The average spot was about two mm. long. In cases where infections had taken place close together these golden-yellow spots were merging. By the last of March it was evident that nineteen out of the twenty-three plants transferred had these infections on the leaves and their appearance was in strong contrast to those that had been left in the tent during the winter, showing how the favorable greenhouse conditions had hastened the development of the fungus. By July 1 the spots were about 2–3 mm. in length, though by merging some were even 6 mm. long. However by this time the spots were past their prime as some of the leaves containing them were dying or drying up. At least one plant was dead and on some of the others the new shoots were killed. It seems evident that, while a few have formed pycnia, none will survive to form aecia.

The two large white pines placed in the tent on September 28 on the date of the last examination (July 8, 1919) failed to show any certain sign of infection. If such had taken place the yellow spots on the leaves have remained obscure. These plants of course were transplanted in the tent much later than the seedlings and were not directly under the bushes, as were the former, so that the conditions for infection were not so favorable.

In Petrie Dishes. Of a score or more of inoculations in Petrie dishes with the pine leaves, both of the fascicled and juvenile forms, we were successful in only two experiments. One of these was on very young seedlings and the other on shoots having juvenile formed leaves. In no case were we able to detect infection on the fascicled leaves. Even on the juvenile leaves the spots were so slight as to require careful inspection with a lens to

determine their presence. Four out of six seedlings in one case showed a few spots which were identified by microscopical sections as containing the rust. Of the five shoots in the other case, infection was positive in two and probably in two more. All these infections were first identified about five weeks after inoculation by which time most of the Petrie dish cultures were usually in poor condition through molds, etc. These spots were first visible somewhat later than the earliest signs found in potted plants in the greenhouse. The length of time required after inoculation before infection shows makes this a rather unsatisfactory method for telial inoculation as compared with the same method for inoculation on *Ribes* leaves.

In Greenhouse. (a) Stems. In the two years, inoculations were made on thirty-five cut and fourteen uncut stems and not a single one of these forty-nine cases has shown any evidence that the inoculation was successful. This seems somewhat contradictory to the results obtained by investigators with other species and with the apparent result obtained by Spaulding with this method. We are not certain whether the latter used any precautions in preventing infection through the leaves. We do not wish to state positively that infection cannot take place through the stem, either wounded or unwounded, because we were unsuccessful in our attempts. Possibly the small size of the stems through which we attempted inoculations may have had something to do with the failure. There is no question that on very vigorous green shoots stomata occasionally occur and it is not impossible that the germ tubes of sporidia may gain entrance through them. Their small number and the difficulty of the sporidia sticking to the stem, however, would make the chance of infection slight as compared with that of the leaves.

(b) Buds. During the two years inoculations were made on the opened buds of twelve plants, seven of which were successful. On the unopened buds fourteen inoculations were made in 1917 and ten in 1918. Of these only two were successful, both made in 1917, and it is not certain whether these buds can be strictly considered as unopened. Our classification of buds as opened and unopened, too, in 1917 was not so clear cut as in 1918. In one of the plants the permanent slide shows, by the presence of a definite sclerotial mass some distance from the base, that infection took place through a scale which had become elongated,

green and needle-like. In the other plant evidence is lacking how infection took place as sections were not made until the tissues of the young stem had become thoroughly invaded.

From the results of these experiments it seems that infection can readily take place through opening buds or shoots which have exposed leaves containing stomata. On the other hand it seems quite certain that infection does not take place through an unopened bud closely enwrapped by the scarious brown scales. In some cases these scales, however, continue their development into modified leaves and, through the stomata of such, infection no doubt may take place as in the case cited above.

(c) Leaves. As has just been noted infection readily took place through the leaves. In fact so far as we can determine of the one hundred successful inoculations reported in Table 6 all, except in the two very doubtful cases already cited, were traceable to leaf infection. The very first sign of infection to the naked eye, visible usually about a month or two after inoculation, or even earlier with a hand lens, is a very small yellowish spot *centering in the lines of stomata* that run lengthwise of the leaf (Pl. XL, fig. 3). These infected leaves later showed *evident golden-yellow encircling spots* (Pl. XL, figs. 1–2) *which were filled with characteristic sclerotial masses of the fungus,* even when there was no mycelium in the stem. Eventually, however, it appeared there at the base of these infected leaves. Sections through the yellow spots also definitely proved that *infection took place through the stomata* as indicated by a characteristic substomatal vescicle directly below the guard cells. Details of infection and the nature of the substomatal vescicle will be discussed later. Suffice it to say here that there was always found in microscopic sections of the yellow spot, usually about the center and beneath a stoma, a substomatal vescicle with a primary hypha leading down to the sclerotial mass (Pl. XLI, fig. 2; Pl. XLIII, figs. 1–6). For example, in one leaf nineteen distinct yellow spots were counted and sections of this leaf showed at least twenty-one substomatal vescicles. In some cases the number of infections as indicated by yellow spots was obscured by the latter running together (Pl. XL, fig. 6) and in a few instances we found two substomatal vescicles below one stoma signifying two infections at this place.

So far as types of leaves are concerned infections were secured readily through both the juvenile and fascicled forms. The former

because of their flattened and somewhat grooved upper surface, thereby more readily retaining sporidia, are perhaps somewhat easier infected. As to age we succeeded in infecting leaves from the very young juvenile stage to those of fascicled form one and even nearly two years old. There did not seem to be any difference as to the part of the leaf involved (base, middle or apex) since infection readily took place all over (Pl. XL, fig. 1), except that the bases of the leaves may have afforded better chances for the sporidia to adhere.

Quite variable results were obtained with different methods of inoculation. The most successful was the one in which the *Ribes* stems with fresh infected leaves were stuck in the crock over the pines. This method approaches nearest to natural conditions. Of thirty-six plants in eight different crocks inoculated on Oct. 19 and 22, 1918, all but one were infected. Not only was this high percentage of infection secured but the many yellow spots on the leaves showed that the infections had been very numerous on each plant. Of these plants fifteen were three years old and twenty-one were seedlings of less than six months. Infections of the latter was so severe that at the present writing practically all have been killed. Fair results were also obtained where water containing telial columns was sprinkled over the plants especially those containing young shoots. The poorest results were given where the infected leaves were put on the soil under the pines, only one out of ninety plants becoming infected. Where such leaves were placed over the pines the results were better.

Percentage of infection does not alone explain the value of the method employed, since a single plant infected through a single leaf is not comparable to another plant infected through many places on numerous leaves. While the method of infection may have had considerable to do with the results obtained, the time of infection also seems to have been a factor. During the two years, on the whole, the best results were obtained during October. Infections, however, may take place at any time sporidia are produced in good condition, since we infected a plant in one instance in June.

Age of Plants. Out of two hundred and thirteen plants inoculated in 1917, one hundred and thirty-three were one year, and eighty were two years old; and of the twenty-four resulting infections eighteen were one year and six two-year old pines. In

TABLE VI—GREENHOUSE INOCULATIONS

Date	Total No. plants inoc.	Total inf.		Inf. Ribes leaves on soil.		Inf. Ribes leaves over plants.		Inf. Ribes leaves on soil and over plants		Inf. Ribe branches in and spread over plant	
		No.	per cent.	No. inoc.	No. inf.	No. inoc.	No. inf.	No. inoc.	No. inf.	No. inoc.	N i.
1916											
)ct. 21	18	4	22	. .	. .	. .	. .	18	4	. .	.
1917											
lug. 25	21	0	0	16	0	. .	. .	. .	. .	. .	.
lug. 27	9	0	0	. .	. .	. .	. .	. .	. .	. .	.
;ept. 6	57	3	5	32	0	. .	. .	16	3	. .	.
;ept. 12	11	0	0	. .	. .	. .	. .	. .	. .	. .	.
;ept. 14	5	0	0	5	0	. .	. .	. .	. .	. .	.
;ept. 24	9	0	0	9	0	. .	. .	. .	. .	. .	.
)ct. 15	21	4	19	10	1	. .	. .	. .	. .	. .	.
)ct. 16	8	4	50	. .	. .	. .	. .	. .	. .	. .	.
)ct. 17	61	13	21	. .	. .	. .	. .	. .	. .	. .	.
Nov. 1	11	0	0	11	0	. .	. .	. .	. .	. .	.
'otal...	213	24	11	83	1	0	0	16	3	0	
918											
une 13	1	1	100	. .	. .	. .	. .	. .	. .	. .	.
;ept. 30	12	0	0	7	0	5	0	. .	. .	. .	.
)ct. 1	48	9	19	. .	. .	. .	. .	. .	. .	. .	.
)ct. 2	6	3	50	. .	. .	. .	. .	. .	. .	. .	.
)ct. 5	11	1	9	. .	. .	. .	. .	11	1	. .	.
)ct. 7	4	1	25	. .	. .	. .	. .	. .	. .	. .	.
)ct. 8	10	2	20	. .	. .	. .	. .	. .	. .	. .	.
)ct. 9	18	6	33	. .	. .	9	3	2	1	. .	.
)ct. 10	5	2	40	. .	. .	. .	. .	2	0	. .	.
)ct. 11	35	10	28	. .	. .	. .	. .	. .	. .	. .	.
)ct. 19	28	28	100	. .	. .	. .	. .	. .	. .	28	2
)ct. 22	8	7	87	. .	. .	. .	. .	. .	. .	8	
)ct. 26	2	2	100	. .	. .	. .	. .	. .	. .	. .	.
)ct. 29	2	0	0	. .	. .	. .	. .	. .	. .	. .	.
)ct. 30	3	0	0	. .	. .	. .	. .	3	0	. .	.
'otal...	193	72	37	7	0	14	3	18	2	36	3
'otal or 3 yrs.	424	100	23	90	1	14	3	52	9	36	3

1918 of the one hundred and ninety-three pines inoculated (not including the twenty-three inoculated in tent and later transferred to greenhouse) fifty-eight were one year, thirty-six two years, and ninety-nine three years old. This year seventy-two plants became infected, twenty-nine of the one year, four of the two years and thirty-nine of those three years old. While these embraced the various methods of inoculation, they were not exactly the same

OF *Cronartium ribicola* ON *Pinus strobus.*

ꜱ on ꜱ on ves	III spores sprayed over plants.		III spores sprayed over young shoots.		III spores on Buds.				III spores on Stems.			
					opened.		unopened.		cut.		uncut.	
ꞁo. ᴅf.	No. inoc.	No. inf.	No. inoc.	No. inf.	No. inoc.	No. inf.	No. inoc.	No. inf.	No. inoc.	No. inf.	No. inoc.	No. inf.
.	..	..	..	..	..	..	..	..	..	..	..	..
0	..	..	..	..	..	..	..	..	..	..	..	..
0	..	..	..	..	..	..	3	0	3	0	..	..
0	..	..	..	..	..	..	6	0	..	..	..	..
Q	..	..	..	..	..	..	..	..	5	0	..	..
.	..	..	..	..	..	..	..	..	..	..	..	..
.	..	..	..	..	..	..	..	..	..	..	..	..
.	..	..	..	..	5	3	..	..	3	0	3	0
4	..	..	..	..	..	..	..	..	..	..	..	..
0	20	9	..	..	5	2	5	2(?)	12	0	..	..
.	..	..	..	..	..	..	..	..	..	..	..	..
4	20	9	0	0	10	5	14	2(?)	23	0	3	0
.	1	1	..	..	..	..	..	..	..	..	..	..
.	..	..	..	..	..	..	..	..	..	..	..	..
4	12	5	..	..	..	..	4	0	2	0	8	0
0	..	..	3	3	..	..	..	..	..	..	..	..
.	..	..	..	..	..	..	..	..	..	..	..	..
.	4	1	..	..	..	..	..	..	..	..	..	..
.	..	..	2	2	..	..	..	..	5	0	3	0
2	..	..	..	..	..	..	4	0	1	0	..	..
2	..	..	..	..	..	..	..	..	..	..	..	..
0	21	5	3	3	2	2	2	0	4	0	..	..
.	..	..	..	..	..	..	..	..	..	..	..	..
.	..	..	..	..	..	..	..	..	..	..	..	..
.	2	2	..	..	..	..	..	..	..	..	..	..
.	2	0	..	..	..	..	..	..	..	..	..	..
.	..	..	..	..	..	..	..	..	..	..	..	..
8	42	14	8	8	2	2	10	0	12	0	11	0
2	62	23	8	8	12	7	24	2(?)	35	0	14	0

ɔr the different ages of the pines used and so the results would be ffected somewhat by the methods employed. However, each ear the one year old pines gave the highest percentage of infecon. For instance, in 1918, of the inoculated plants fifty per cent. f the one year, eleven per cent. of the two years and thirty-eight er cent. of the three years old became infected. These per cents. ·ere much higher than those obtained in 1917, when only four-

teen per cent. of the one year and eight per cent. of the two years old were infected. In 1918 the conditions for securing infection were much improved by the use of infected *Ribes* leaves still attached to the branches, as one of the methods of inoculation, and by the presence on many of the three years old pines of new shoots, some of which had juvenile-formed leaves. For examples of abundant infections resulting, two hundred and eighty-four yellow spots were counted on thirty-eight leaves of a year old seedling; and one of the three years old pines showed fully as many similar spots on the fascicled leaves. The counts in the former case were made before it was apparent to the eye that the stem was invaded. The young growing seedlings and vigorous growing older plants, especially the younger parts, seem to take infection better than plants that are at a stand-still or somewhat sickly. This appears to be true of bright, dark green leaves as compared with those more or less speckled and not of so healthy a color.

Pycnia and Aecia. There is no question that the younger a seedling is when infected the less chance it has of survival. This is especially true of the very young seedlings, most of which failed to survive a year or even long enough to form the pycnial stage. The new shoots of the older plants, especially where infection took place through their juvenile form leaves, were often dead by the following summer. The number and place of infections, together with the vigor of growth, largely determine the life of the infected pine. Pycnia of the normal type and oozing pycniospores have appeared on a number of these infected pines even including some of those classified as one year old seedlings. The pycnia have been seen four months after inoculation but usually it was five or six months before pycnial drops appeared. Vigorously growing infected stems, when oozing pycnia, are especially subject to attack by chewing animals, apparently slugs, which conceal themselves in the damp soil of the crocks. This has no doubt interfered somewhat with the further development of the rust. In no case yet have aecia appeared on any of the infected plants. Of those infected in 1917 only five remained alive in February, 1919. They were the older and larger plants and it seemed quite possible that aecia might appear on them during the spring. However, by July, they had all been killed by the rust without its further development. Up to date none of the plants infected in 1918 has shown any signs of aecia, though producing

pycnia. However, as a number of these are of the largest size used and apparently growing vigorously, despite the evident infection, there is a possibility that they may produce aecia in 1920. See Table 6 for further details of greenhouse infection.

Other Species Inoculated.

During 1917–18 besides *Pinus strobus* four other five-needled species were inoculated, partly out-of-doors and partly in crocks in the greenhouse. Of these *Pinus excelsa* was inoculated nine different times; *Pinus flexilis,* three different times on five different branches; *Pinus cembra,* once on two different plants; and *Pinus koraiensis,* two different times on three separate branches. Inoculations with *Pinus excelsa* were all, except in two cases, in the greenhouse. The greenhouse plants were four and five years old, while the out of door plant, used both years, was about six to eight years old. The other three species were all out of door plants of the same age. Despite the fact that the rust has been reported on some of these hosts we did not in a single instance secure an infection.

Purely as a matter of curiosity, as successful results were not expected, inoculations were also attempted one or more times on the following two needled pines, all of which except *Pinus densiflora* were grown in crocks in the greenhouse: *Pinus austriaca, P. densiflora, P. resinosa* and *P. sylvestris.* In the case of *Pinus sylvestris,* five one-year old seedlings were used, as such young plants are most likely to become infected, if susceptible. As in the preceding species, none of these inoculations was successful.

DETAILS OF LEAF INFECTION.

Telia and their Germination. As already stated, the telial or III stage of the fungus may be formed on the *Ribes* leaves (Pl. XXXVIII, fig. 1) any time of the year from June on, although in nature they usually begin to appear the latter part of July and are most conspicuous in September and October. They develop more or less thickly on the under side of the leaves as short hairy growths about one or two mm. in length (Pl. XXXVIII, figs. 2–3).

As seen individually under the microscope the reddish-brown telial hairs (Pl. XXXVIII, fig. 4) are found to be composed of a

solid column of spores. These spores are considerably elongated lengthwise of the column, although at the ends they are shorter and broader. The more cylindrical ones (Pl. XXXIX, fig. 1) are 37-60μ x 14–16μ while the shorter apical ones are usually 27–36μ x 18–21μ. Longitudinal sections show that they are formed in chains, those of the interior adhering more loosely together, but often breaking joints so that the telial column is rather permanent although with pressure it may separate into chains or single cells (Pl. XLIV, figs 1–2). Colley (**5** p. 637) gives a comprehensive description of the telia in his excellent paper on the microscopic structure of the blister rust, so that further details are omitted.

The telial spores germinate, *in situ*, anytime after maturity when conditions are favorable (Pl. XXXVIII, figs. 5–6). Apparently each spore may give rise to a promycelium which is sent out from its side as a growth filled with protoplasm, ordinarily reaching a length about that of the spore (Pl. XXXIX, figs. 1–2). This promycelium soon is divided by septa into four uninucleated fertile cells filled with protoplasm and a semi-empty basal cell. (Pl. XLIV, figs. 5–6). From each of the fertile cells (Pl. XXXIX, fig. 3; Pl. XLIV, figs. 7–10) arises a prominent pointed sterigma about the length of the cell. When fully developed, the sterigma forms at its tip (Pl. XXXIX, fig. 4) a swelling into which as it grows passes the entire protoplasm and the nucleus of the cell, forming a spherical sporidium about 10–12μ in diameter (Pl. XXXIX, fig. 5). The sporidium when mature, is easily separated from the narrowed tip. Variation from the normal type of germination of the telia is shown where instead of a promycelium a mycelial-like thread is formed (Pl. XLIV, figs 11–12). Another abnormal type is shown when the cells of the promycelium round up and become separated as kind of sporidia-like bodies (Pl. XLIV, fig. 13). These variations are probably produced under unfavorable conditions of aeration such as are often obtained in van Tieghem cell cultures.

The sporidia are comparatively short-lived and germinate immediately under favorable conditions of moisture. Usually a single germ tube is sent out (Pl. XXXIX, fig. 6; Pl. XLIV, fig. 16) tapering somewhat towards the tip. In cultures this germ tube may reach a length several times that of the spore and may be more or less curled (Pl. XLIV, figs. 18–19) and rarely gives rise to a short branch (Pl. XLIV, fig. 22). Occasionally sporidia are found

which have two or three germ tubes developing (Pl. XLIV, figs. 15, 17, 21, 22).

Often a sporidium instead of forming an infection tube gives rise to a tapering sterigma about twice its length, on the tip of which is produced a secondary slightly smaller sporidium (Pl. XXXIX, fig. 7; Pl. XLIV, figs. 23–25). As apparently only a single one is produced, this formation of a secondary sporidium is probably to tide it over unfavorable conditions of infection. These data were obtained partly from the germinating telia *in situ* and partly from those placed in watch crystals and van Tieghem cells.

Infection through Stomata. When a sporidium is blown to a leaf no doubt it germinates in the manner as described above by sending out a germ tube. Contrary to the general belief this does not penetrate the epidermis but gains entrance through a stoma. So far it has not been possible to verify this statement by a direct microscopical examination showing the sporidium germinating on the outside of the leaf and the germ tube pushing between the guard cells of the stoma into the air chamber beneath. The reasons for this are that not sufficiently young infections, those less than a week old, have been examined, and the exceedingly great difficulty in locating points of infection, since there is no external evidence to guide one within three or four weeks after this takes place, by which time the delicate sporidium and its germ tube outside the stoma are obliterated.

The indirect evidence, however, is sufficient to prove that the germ-tube of the sporidium passes down between the guard cells of a stoma. The youngest stages in which we have been able to find infection was fifteen days after the sporidia had been placed upon the leaves. In this, as well as in numerous older stages where yellow spots indicated the general point of infection, there was always evident just beneath the guard cells (Pl. XLI, fig. 1) a characteristic substomatal vescicle, mention of which has already been made. We have never seen in any of our sections evidence that the germ tube penetrated directly through the cuticle into or between the epidermal cells. In fact we do not recall having seen any hyphae in the epidermal cells. On the other hand whenever we have sectioned a leaf through a small yellow spot, we have been able to obtain at least under one stoma the substomatal vescicle. This substomatal vescicle we consider to be an inflation of the germ tube immediately it has passed the guard

cells into the air chamber. There is always a beak-like elongation passing from the upper end of the vescicle and often projecting quite up to the central bulge of the guard cells (Pl. XLIII, fig. 6) where evidently the germ tube entering into the leaf becomes most constricted and is most likely to be severed.

Substomatal Vescicles. A substomatal vescicle is a characteristic swelling of the mycelial thread never found except just beneath a stoma. As already stated it always ends above in a short beak projecting up between the guard cells. This beak (Pl. XLIII, figs. 1–6) varies from 2 to 22μ in length according as the section passes directly through the centre of the substomatal vescicle or to one side. It ends in a sharp point where the guard cells approach nearest together and below joins directly to the centre of the substomatal vescicle by a base about the usual width of a hypha. The substomatal vescicle in general is ovate to elliptical and is elongated in the direction toward the stomal pore. The general size of the vescicle is about 7–11μ by 10–13μ. This substomatal vescicle at least at first is filled with protoplasm, and has a single nucleus (Pl. XLIII, figs. 1–3). The beak and wall of the vescicle often become somewhat thickened.

Primary Hyphae. From the lower end of the substomatal vescicle there develops a thread (Pl. XLIII, figs. 1–5) about 2.5 to 3.5μ wide which usually grows straight down toward the base of the air chamber. Sometimes it turns to one side and comes in contact with the parenchyma cells there, thus forming a shorter tube. This we call the primary hypha because it is the first representation of the mycelium within the leaf and is distinguished from the other hyphae in the immediate vicinity by its comparatively straight and rarely septate tube. Accordingly as it first comes in contact with parenchyma cells at the side or base of the air chamber, we have found it to vary from 9 to 40μ in length. Once it comes in contact with a parenchyma cell a branch proceeds from its side and by the narrow penetrating tube enters within the cell to form the characteristic finger shaped haustorium (Pl. XLIII, fig. 1). A source of food supply now being assured secondary hyphae of the mycelium as described later are formed.

With the penetration of the aecial and uredinial spores through the stomata in *Ribes* we have found a swelling outside the stoma as well as beneath it. Whether or not such a swelling occurs in the germ tube of the sporidium on the pine we cannot state.

We have interpreted these external swellings (appressoria) not only as hold fasts but also as reservoirs of food for favoring successful and rapid entrance into the leaf. Likewise the substomatal vescicle not only acts as a hold fast which would prevent the germ tube from being pulled out through the stomatal pore because of greater width but also as a storehouse of food for the rapid development of the primary hypha.

Mycelium. The primary hypha having formed a haustorium begins the development of the mycelium. This (Pl. XLIII, figs. 4–5) differs from the primary hypha by the curled character of the threads which are also frequently branched and septate. The cells of the mycelium are usually much longer than wide, though in this respect there is considerable variation. Usually they vary from 2 to 6μ wide by 16 to 21μ long. The greatly branched and curled hyphae (Pl. XLIII, fig. 6) soon begin to form compact masses in which it is impossible to trace the individual threads. In the meantime some of the hyphae have penetrated the host cells by haustoria.

Haustoria. The haustoria enter the host cells by a very narrow penetrating tube which bores through the cell wall and after gaining entrance into the cell assumes its normal diameter of about 3 or 4μ. In general the haustoria (Pl. XLIII, fig. 4) are enlongated, finger-like bodies filled with protoplasm and may reach a length of 50μ or more. In the leaf two nuclei have been noted in one haustorium, though in the stem the haustoria are uninucleate. The usual tendency of the haustorium is to extend toward the center of the cell where the nucleus is situated. There seems to be a sort of attraction by the nucleus since the haustorium frequently forms an abrupt bend (Pl. XLIII, fig. 6) and partially encircles the nucleus or makes a depression in it, but apparently does not penetrate its membrane. The haustoria usually are simple but occasionally have one or two branches (Pl. XLIII, fig. 7 j) which may be more or less curled and mycelium-like with an occasional septum.

Sclerotia. The curled hyphae eventually form a very compact cellular mass much like sclerotia (Pl. XLIII, fig. 7m). The chief differences between these and typically free sclerotia consist in their greater variation in size and shape, and the lack of any differentiated bounding layer. The appearance of these sclerotial masses varies largely according as the section of the leaf is transverse or longitudinal. In the former (Pl. XLII, fig. 1) they are

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much like normal isolated sclerotial bodies though frequently there seems to be some coalescing of separate masses. In general they are nearly spherical but with occasional irregularities due to coalescence. The size of the sclerotia depends upon their age. Three months or more after infection, with the yellow spots on the leaves very conspicuous, they may extend from epidermis to epidermis and destroy the substomatal vescicle, the evidence of the point of infection. Some of the larger sclerotia thus reach 400μ in diameter. They begin their development in the intercellular spaces causing pressure against the host cells, and such cells being enclosed in the sclerotial mass are finally disintegrated though occasional traces of them may be detected. Distortions of the vascular system and other tissues of the leaf may be seen as the result of this exaggerated growth of the mycelium. The color of the yellow spots as seen by the naked eye is due to the destruction of the chloroplasts in the cells of the host rather than to any pigment in the walls or protoplasm of the fungus. The parenchyma cells immediately surrounding the sclerotial masses contain chloroplasts with a sickly yellowish appearance. In other words the endochrome evident in the mycelium directly producing the spore stages is not found here.

In longitudinal sections (Pl. XLI, fig. 3) the sclerotia more frequently have the appearance of a compound structure or of individual sclerotia running together. This is due to the laminate structure of the leaf, as seen in longitudinal sections, where the fungus forms individual masses in the various intercellular chambers and eventually coalesce through continued growth.

The function of these sclerotia is somewhat in doubt. It was first thought that they might be the beginning of the pycnial stage, but no evidence of the development of pycnia on the surface of the leaf above them has ever been seen. The fact that they begin their development in the fall and that in the fully matured and old sclerotia in midsummer there is some evidence of slight disintegration of the internal cells, leads us to believe that they act as storehouses to insure the penetration of the fungus through the vascular system of the leaf into the stem. The stem penetration at times may prove a slow process especially when the point of infection is near the tip of the leaf. In such a case the fungus in the sclerotial stage may remain more or less quiescent during the winter and the final penetration of the stem be delayed until the

next spring or early summer. Such a sclerotial mass would insure final penetration much more certainly than a slight mycelial growth.

Invasion of Vascular Region. Once a sclerotium is developed in the tissues of the leaf it may encroach on the vascular system; that is, while the sclerotium at first is entirely in the mesophyll, it may eventually break through the endodermis (Pl. XLII, fig. 2) and be partially enclosed by the same. As sections are taken below the yellow spots the sclerotium gradually fades out of the region of the mesophyll and becomes limited to larger or smaller sclerotial masses in the parenchyma of the vascular region. Very soon all evidence of sclerotium and mycelium disappears from the mesophyll. Haustoria may invade the endodermal or parenchymatous cells of the vascular region. If the sclerotial masses reach the xylum side of the bundle small sclerotial masses or mycelial strands gradually find their way to the phloem.

Sections through the perfectly green leaf some distance below the yellow spot of infection now show the fungus entirely limited to this position within the vascular system. In cross sections of the leaf made still further down it is found that the mycelial strands become very limited in number, seldom branched and grow almost entirely in the longitudinal direction toward the base of the leaf on the phloem side of the bundle. If a single point of infection happens to occur near the tip of the leaf and sections are thus made far below it, it is almost impossible to distinguish the fungus (Pl. XLII, fig. 3) from the phloem since the hyphae in cross sections are so similar in size (3–5μ), shape and staining as scarcely to be differentiated from the smaller phloem cells. In the larger phloem cells haustoria have been seen and in some of the smaller ones their contents sometimes look like mycelial strands.

Invasion of the Stem. As the mycelial strands, running lengthwise in the needles in contact with the phloem, reach the base of the leaf, they begin to go out again between the cells of the mesophyll which in this region, however, is not so definitely marked off by the endodermis. Growing beyond the endodermal cells the fungus finally reaches down into the cortex developing haustoria abundantly in the host cells as it proceeds. Once within the stem the mycelium grows uniformly throughout the bark and causes a stimulus in its growth. This is manifested in seedlings of one to three years old by slight swelling of the stem and upon the green

younger parts by a general yellowish discoloration, these being the first evidence to the naked eye of stem invasion. Only rarely, however, have we found a distinct discolored spot on the stem at the base of the leaf fascicle through which the infection took place.

The mycelium now becomes very abundant in the young tissues of the stem. If the infected leaf happens to be situated on a stem a year or two old invasion is not so rapid or prominent to the naked eye as when it is situated on green parts of a very young growing stem. Entrance here seems to be almost certain death to the terminal parts before the end of the summer. Heavy infection of the stem before the leaves have made their full growth causes a stunting and bunching of the same (Pl. XL, fig. 5), a characteristic which is employed in plantation or seed-bed inspections for identifying the fungus before the appearance of its fruiting stage. In very young stems the swelling and discoloration may be accompanied by a bending of the terminal part (Pl. XL, fig. 4).

Heavy infection through many leaves checks in part the later development of the fungus, since the invaded shoots may be killed before the fruiting stages are formed. However, if this is only a lateral shoot, or if the plant is of some size the fungus may yet form its fruiting stage elsewhere. In none of our sections have we found that the mycelium directly invades the growing point, it usually being some distance below where the cells have about reached their normal size.

We have occasionally seen cases where the fungus evidently went up from the invaded stem into the new leaves situated on it and at the base of these, or even isolated a short distance above, formed yellow spots quite similar to those of the primary infections made through the stomata. Such spots seen late in the season might possibly be mistaken for original infection areas. We are not sure, either, that primary infections may not occasionally form secondary isolated yellow spots on the leaves below the point of entrance. We are certain, however, most of the yellow spots that have appeared on our infected plants are primary infection areas, even when many showed in a leaf, since they have appeared simultaneously a comparatively short time after the infection took place.

Appearance of Pycnia and Aecia. While we cannot state, from our experiments, the time of the development of the pycnia in outdoor infections, we presume that this usually takes place sometime during the early summer succeeding the fall infection, since this was the case with Klebahn's experiments (**9**). In our greenhouse infections however they have shown as early as February, and on young stems of sufficient diameter have formed slightly elevated yellowish and eventually reddish-brown areas similar to those occurring in nature. On these evident pycnial drops with normal pycniospores have appeared. Preceding development of pycnia microscopical sections show an exaggerated development of mycelium in the cortex slightly below the epidermis and from this mass are developed the erect, closely packed, fertile, pycnial threads, from the ends of which are abstricted the pycniospores as has been described in detail by Colley (**5** p. 629).

In nature the aecial stage develops from more deeply imbedded sclerotial masses in the year following the appearance of pycnia. Unfortunately in none of our indoor infections has this stage been produced, so that details of the time and manner of its appearance cannot be given here.

Cycle of Development. From the sum total of our observations and experiments we may summarize the development of the fungus as follows:

1st year. Infection occurs from late summer to late fall through the leaves, producing at most very inconspicuous yellowish spots at the point of invasion. In rare cases it may be that these spots develop more conspicuously and invasion of the stem takes place before winter sets in.

2nd year. During spring and early summer the yellow spots on the leaves become more or less conspicuous; later there is invasion of the stem causing slight swelling and discoloration and possibly in certain cases pycnia are produced.

3rd. year. There is further swelling of the stem and possibly stunting of the leaves with pycnial development during the summer or (in case pycnia were found the previous year) with aecial formation in the spring.

4th. year. There may be formation of aecia. In cases of slight or localized infection, especially in hardened tissues, it may be that the formation of pycnia and aecia is delayed for even a longer time.

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EXPLANATION OF PLATES.

Plate XXXVII.

Methods of inoculating leaves of white pine with blister rust, ***Cronartium ribicola.***

Fig. 1. Inoculated fascicled leaves in a Petrie dish.

Fig. 2. Leaves inoculated at definite points, marked by strings, under battery jar.

Fig. 3. Young terminal shoots inoculated under bell jar, parts below protected by covering of cotton and paper.

Plate XXXVIII.

Telial stage of the blister rust on currants.

Fig. 1. *Ribes nigrum* with telial stage on under surface of leaf. Slightly reduced.

Fig. 2. Same as fig. 1, showing portion of leaf surface slightly magnified and telial columns quite evident.

Fig. 3. Portion of fig. 2, still more highly magnified, about 7 diameters.

Fig. 4. Two telial columns, dimly showing cellular structure, extending from fragment of leaf at base. Magn. about 70 diam.

Figs. 5–6. Portion of telial columns sending out germ threads; fig. 6 also showing a fully developed promycelium with sporidia. Magnified about 135 diams.

Plate XXXIX.

Photomicrographs of the development of the promycelium from telial spores. All magnified about 760 diams.

Fig. 1. A single telial spore sending out a germ thread, the beginning of the promycelium.

Fig. 2. A nearly fully grown promycelium growing out of a cell of the telial column.

Fig. 3. Similar to fig. 2, but with promycelium septate and a single sterigma developed.

Fig. 4. Similar to fig. 3 but sterigmata forming young sporidia on their tips.

Fig. 5 An isolated promycelium with two empty fertile cells bearing fully developed sporidia, the other two filled with protoplasm and just starting the formation of the sterigmata, and the empty sterile basal cell.

Fig. 6. Sporidia just starting to germinate.

Fig. 7. A sporidium germinating and forming a secondary sporidium.

Plate XL.

Infected leaves and seedlings of white pine from greenhouse inoculations showing characteristic golden-yellow spots, etc.

Fig. 1. Fascicled leaves taken from a pine (No. 623) about 10 months after inoculation, showing a few of the several hundred infection spots that developed within four or five months after the inoculation. Slightly reduced.

Fig. 2. Juvenile leaves from an inoculated pine showing single infection spots. Slightly magnified.

Fig. 3. Leaf showing origin of very young infection spots directly over stomatal rows. Magnified about 18 diams.

Fig. 4. Infected seedling pine with juvenile leaves showing swelling, discoloration and bending of invaded terminal shoot.

Fig. 5. Artificially infected pines showing bunching and dwarfing of young fascicled leaves.

Fig. 6. Pine leaf showing how partially developed, closely-placed infection spots may run more or less together. Magnified about 12 diams.

Plate XLI.

Photomicrographs of cross and longitudinal sections of infected pine leaves. a-e, host cells; f-i, fungous cells:–a. epidermis, b. stoma, c. guard cells, d. cells of mesophyll, e. vascular system, f. substomatal vescicle, g. primary hypha, h. mycelium, i. sclerotium.

Fig. 1. Cross section showing a substomatal vescicle and primary hypha beneath a stoma, and further in fragments of the mycelium out of focus. Magnified about 400 diams.

Fig. 2. Portion of fig. 1, more highly magnified, about 800 diams.

Fig. 3. Longitudinal section showing sclerotial masses on either side of vascular system. Magnified about 60 diams.

Plate XLII.

Photomicrographs of cross sections of infected pine leaves, showing leaf structure and sclerotial stage of rust. Magnified about 120 diams. a-e, host-cells; f-g, fungous cells:–a. epidermis, b. mesophyll; c. endodermis, d. phloem side of bundle, e. xylem side of bundle, f. sclerotial mass of rust, g. vascular invasion threads.

Fig. 1. Sclerotial mass of rust in mesophyll to one side of vascular system.

Fig. 2. Sclerotial mass within endodermal sheath of vascular system.

Fig. 3. Mycelium of rust limited to a few invasion threads on phloem side of bundle shown by the darker stained cells.

Plate XLIII.

Cross sections of infected leaves of *Pinus strobus*. Magnified about 450 diams. a-f, host cells; g-m, fungous cells:–a. epidermis, b. stoma, c. guard cells, d. cells of mesophyll, e. chloroplasts, f. nucleus, g. substomatal vescicle, h. substomatal beak, i. primary hypha, j. haustorium, k. mycelium, l. nucleus, m. sclerotium.

Fig. 1. Section of leaf showing a stoma with a substomatal vescicle below it and a haustorium developed from the primary hypha. Int. no. 617 (2); inoculated Oct. 11, 1918, killed Nov. 8, 1918. Slide 11/8/18/(2). 2.

Fig. 2. Section of leaf showing a stoma with a substomatal vescicle having an elongated beak and the straight primary hypha. Pine inoculated Oct. 8, 1918, killed Nov. 9, 1918. Slide 11/9/18. 2.

Fig. 3. Section of leaf showing a stoma with substomatal vescicle cut somewhat diagonally and the long primary hypha. Inf. no. 617 (2); inoculated Oct. 11, 1918, killed Nov. 19, 1918. Slide 12/19/18/(1). 3.

Fig. 4. Section of a leaf showing a stoma with a substomatal vescicle below it and the primary hypha in contact with a host cell and developing mycelium. Inf. no. 617 (2); inoculated Oct. 11, 1918, killed Nov. 19, 1918. Slide 12/19/18/(1). 1.

Fig. 5. Section of leaf showing part of a stoma with a substomatal vescicle beneath and the long primary hypha ending in curled hyphae encircling a host cell. Inf. no. 617 (3); inoculated Oct. 11, 1918, killed Dec. 19,1918. Slide 12/19/18 (2). 3.

Fig. 6. Section of a leaf showing a stoma and a substomatal vescicle with a very much shortened primary hypha and a well developed mycelium. Inf. no. 626; inoculated Oct. 19, 1918, killed Jan. 6, 1919. Slide 1/6/19 (3). 3.

Fig. 7. Section through a small sclerotial mass in a pine leaf. Inf. no. 624 (2); inoculated Oct. 19, 1918, killed Dec. 17, 1918. Slide 12/17/18 (4). 16.

Plate XLIV.

Drawings of fresh material of telial stage. Figs. 1–2, 6, 11–13, magnified about 450 diams.; figs. 3–5, 7–10, 14–25, magnified about 650 diams. a. nucleus of teliospore, b. germ tube of teliospore, c. sporidium, d. fertile cells and e. sterile basal cell of promycelium, f. germ tube of sporidium, g. secondary sporidium, h. sterigma.

Fig. 1. Part of chain of teliospores taken from middle of column.

Fig. 2. Part of chain of teliospores taken from apical end of column.

Fig. 3. A teliospore with a single germ tube starting to form the promycelium.

Fig. 4. A teliospore with two germ tubes starting.

Fig. 5. A fully grown promycelium with four fertile cells and one sterile basal cell.

Fig. 6. A promycelium with cells starting to form sterigmata.

Fig. 7–10. Promycelia with mature sterigmata and sporidia in various stages of development; some of the fertile cells not yet germinating.

Figs. 11–13. Unusual types of germination of telial spores—showing in fig. 11 a branched germ tube, in fig. 12 a simple wavy germ tube, and in fig. 13 the fertile promycelial cells rounding directly into sporidia-like bodies.

Figs. 14–25. Sporidia in different stages and types of germination; 14, 15, 17, 21, 22, sporidia with more than one germ tube; 16, 18, 19, 20, sporidia with single germ tubes; 23–25, sporidia forming sterigmata with secondary sporidia.

Fig. 1.

Fig. 2.

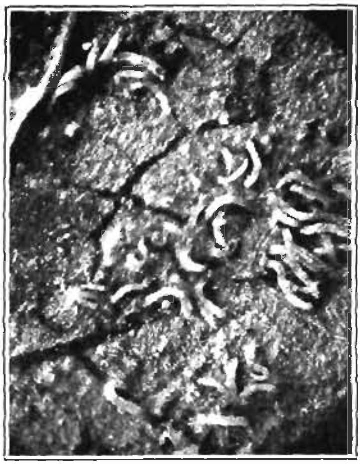


Fig. 3.

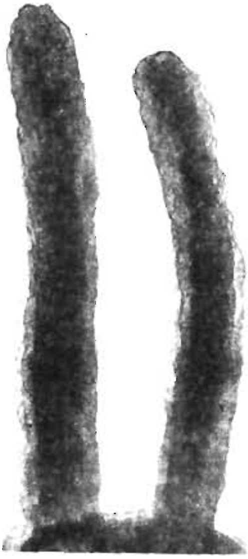


Fig. 4.

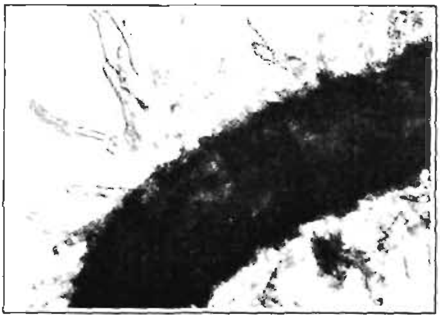


Fig. 5.

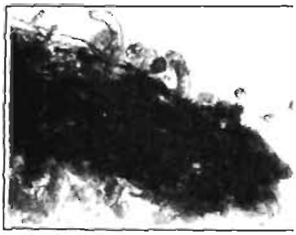


Fig. 6.

TELIAL OR III STAGE ON RIBES.

PLATE XXXIX.

Fig. 1.

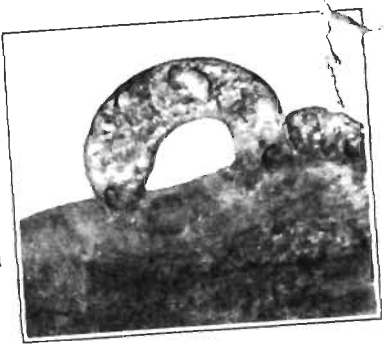


Fig 2.

Fig. 3.

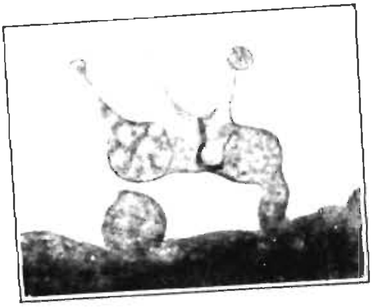


Fig. 4.

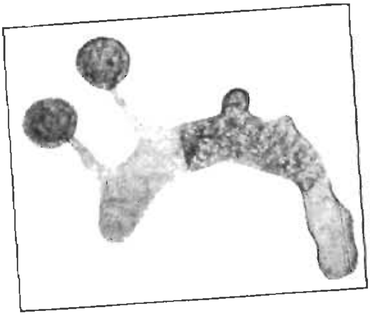


Fig. 5.

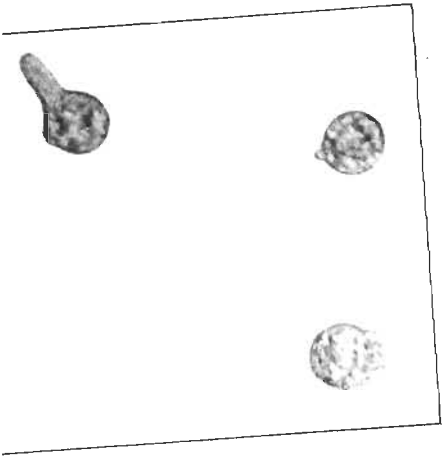


Fig. 6.

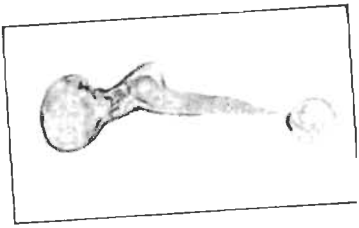


Fig. 7.

GERMINATION OF TELIAL STAGE.

PLATE XL.

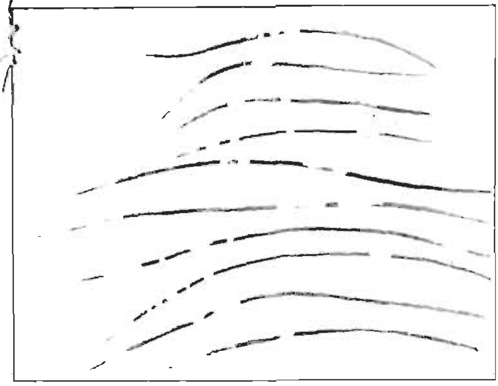
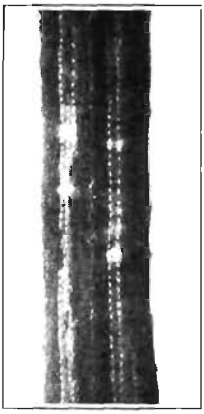


Fig. 1.

Fig. 2.



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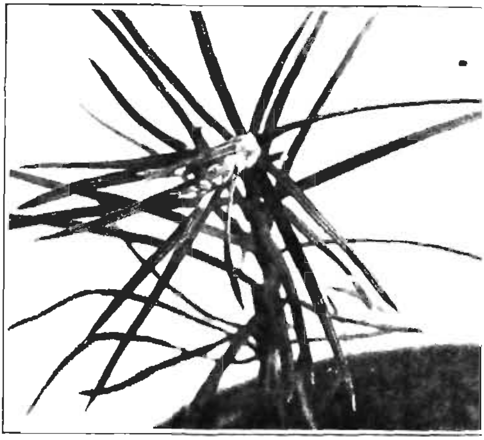


Fig. 4.

Fig. 5.

Fig. 6.

INFECTED PINE LEAVES AND STEMS.

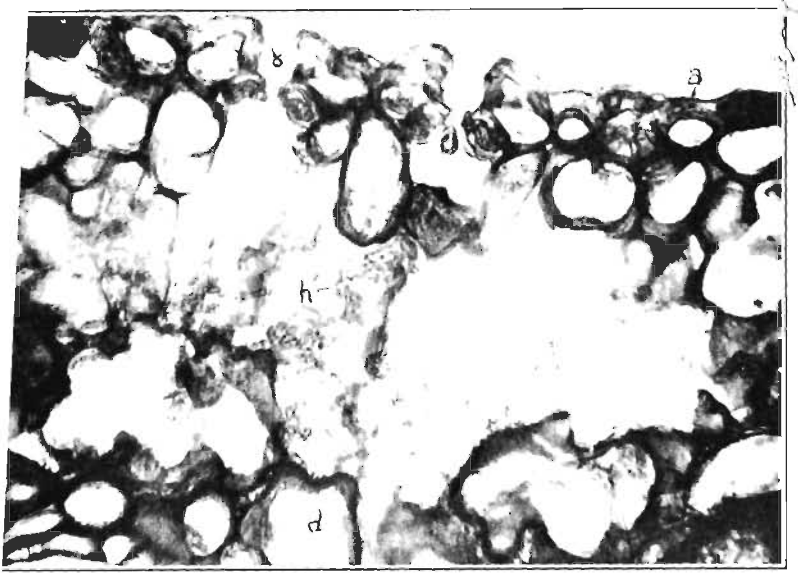


Fig. 1.

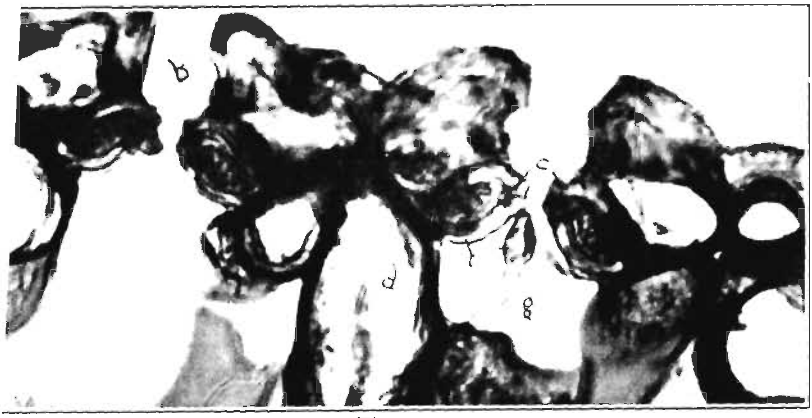


Fig. 2.

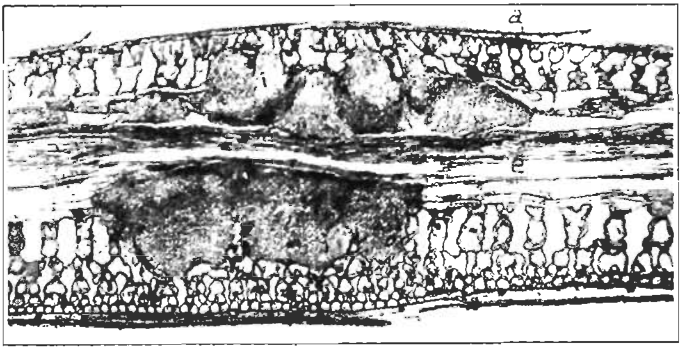


Fig. 3.

CROSS AND LONGITUDINAL SECTIONS OF INFECTED PINE LEAVES.

PLATE XLII.

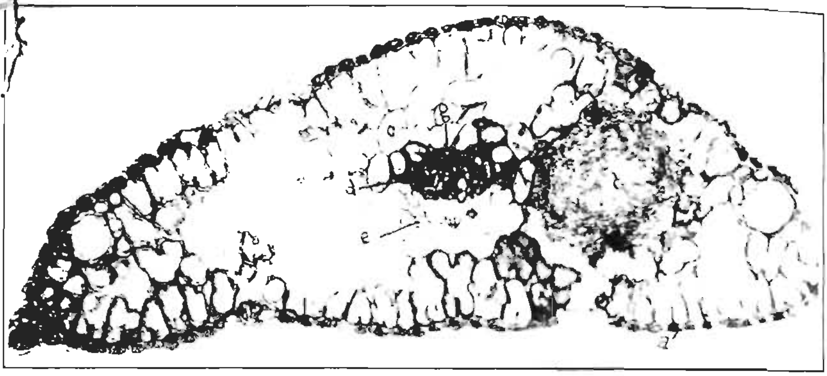


Fig. 1.

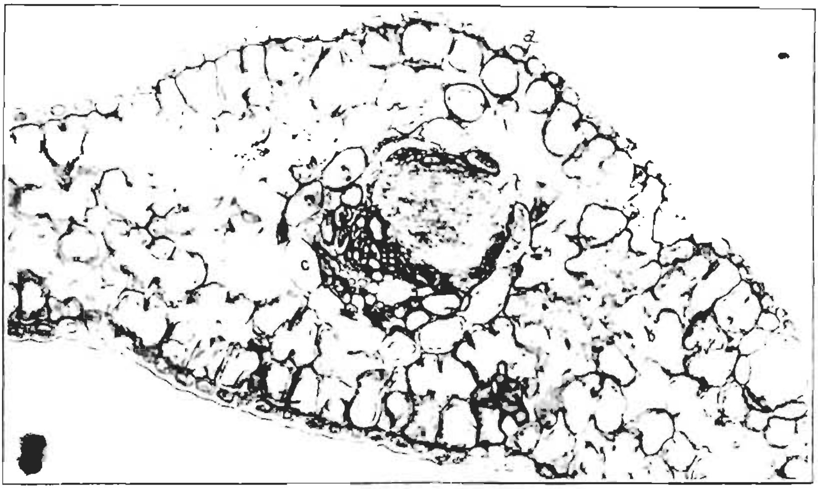


Fig. 2.

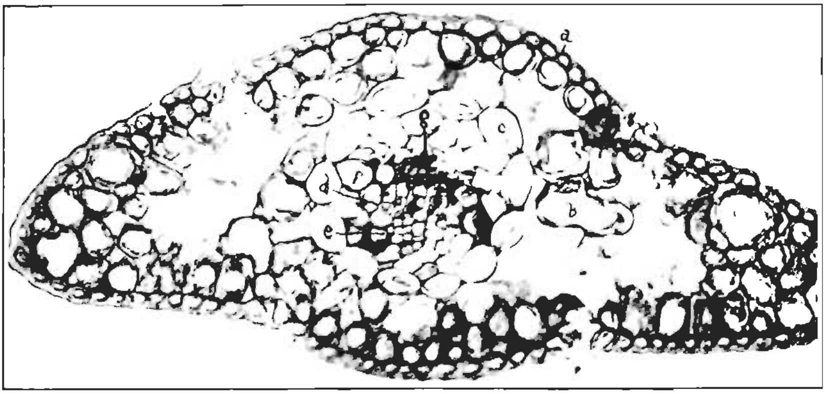


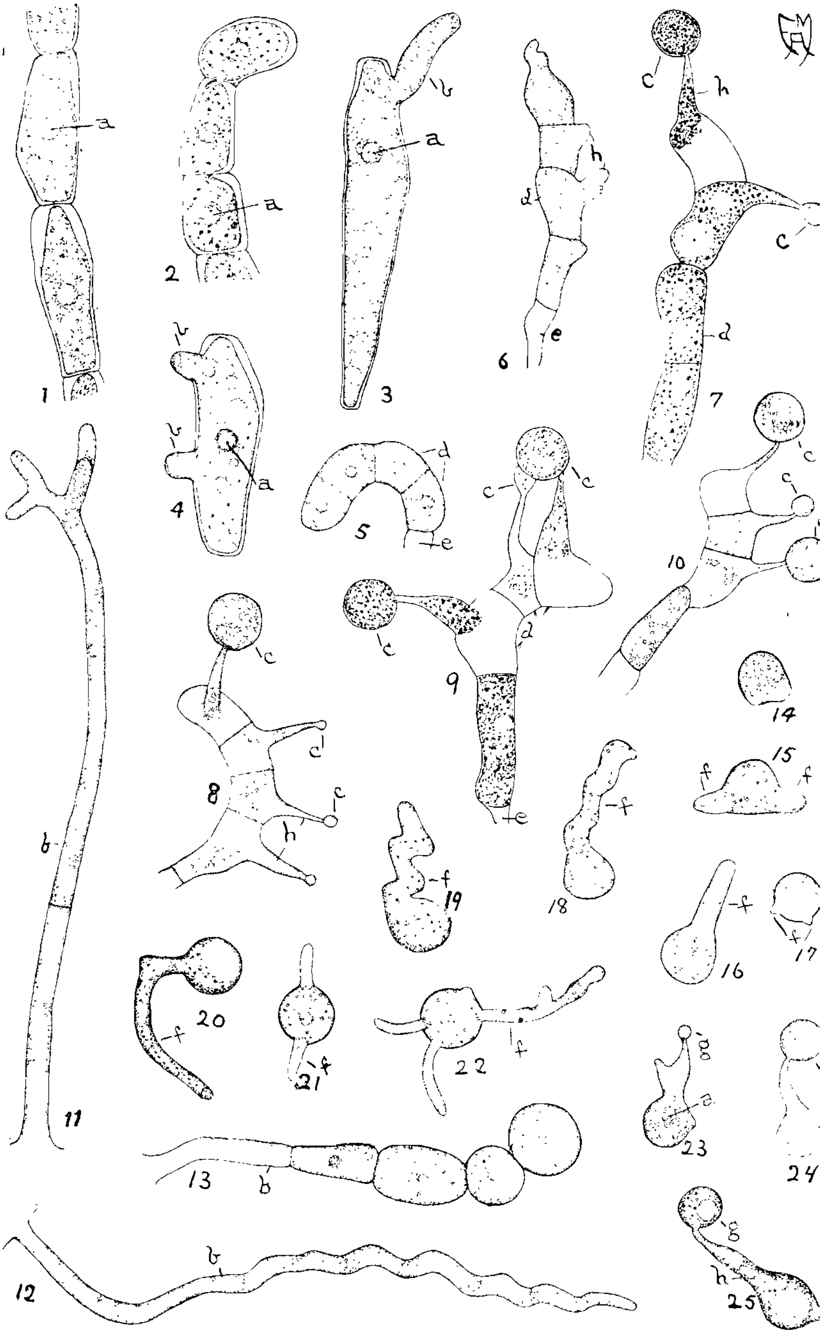
Fig. 3.

CROSS SECTIONS OF INFECTED PINE LEAVES.

CROSS SECTIONS OF INFECTED PINE LEAVES.

CROSS SECTIONS OF INFECTED PINE LEAVES.

PLATE XLIV.



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